PB 203 619

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
Springfield, Va. 22151

BIBLIOGRAPHIC DATA SHEET	1. Report No. EPA-SW-22c-71	2.	3. Recipient's Accession No.

4. Title and Subtitle
RUBBER REUSE AND SOLID WASTE MANAGEMENT. PART I - SOLID WASTE MANAGEMENT IN THE FABRICATED RUBBER PRODUCTS INDUSTRY, 1968. PART II - WASTE RUBBER AND ITS REUSE, 1968

5. Report Date
1971

6.

7. Author(s)
Robert J. Pettigrew and Frank H. Roninger

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Uniroyal Chemical
Division of Uniroyal, Inc.
Naugatuck, Connecticut 06770

10. Project/Task/Work Unit No.

11. Contract/Grant No.
PH 86-68-208

12. Sponsoring Organization Name and Address
U.S. Environmental Protection Agency
Office of Solid Waste Management Programs
Rockville, Maryland 20852

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstracts

The study defines the solid waste management problem of the fabricated rubber products manufacturing industry for the production year 1968 and examines the reuse potential of the industry's waste, as well as the reuse potential of worn out rubber waste from the consumer, mostly tires and inner tubes. In the manufacture of 10.7 billion pounds of salable rubber products in 1968, it is estimated that 1,058 million pounds of solid wastes had to be disposed of at the fabricating locations and at a disposal cost of about $9.5 million. In most cases, contractors haul solid waste from the plant site for disposal elsewhere, generally to a landfill. For the entire industry, the weighte average cost for both in-plant collection and offsite disposal approximates $18 per ton of solid waste. In the rubber industry, retreaders, reclaimers, and tire splitt are reusing and recycling solid waste; however, the trend is downward for recycle o reuse. Other possibilities for reusing rubber product waste are discussed.

17. Key Words and Document Analysis. 17a. Descriptors

*Refuse disposal, *Rubber, *Rubber industry, Automobile tires, Tires, Salvage, Reclamation

17b. Identifiers/Open-Ended Terms

*Solid waste disposal, *Waste rubber, Recycling, Reuse, Retread industry, Reclaime rubber industry, Tire splitting industry

17c. COSATI Field/Group 13B

18. Availability Statement
Microfiche copy - NTIS
Paper copy - Superintendent of Documents,
Washington, D. C. 20402, SN 5502-0028

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class (This Page
UNCLASSIFIED

21. No. of Pag
122

22. Price
$1.25

Rubber Reuse and Solid Waste Management

Part I

SOLID WASTE MANAGEMENT IN THE FABRICATED RUBBER PRODUCTS INDUSTRY, 1968

Part I of this publication (SW-22c) was written
for the Federal solid waste management program by
ROBERT J. PETTIGREW and FRANK H. RONINGER
Uniroyal Chemical, a division of Uniroyal, Inc.
under Contract No. PH 86-68-208

U.S. ENVIRONMENTAL PROTECTION AGENCY
1971

Preface

This report on solid wastes generated by the operations of the fabricated rubber products industry was prepared by Uniroyal Chemical, a division of Uniroyal, Inc., pursuant to contract PH 86-68-208 with the Federal solid waste management program (now part of the U.S. Environmental Protection Agency). The statements, findings, conclusions, recommendations, and data in this report are not necessarily those of the Agency, nor does mention of commercial products imply endorsement by the U.S. Government.

The principal investigator was Robert J. Pettigrew with the support of the Commercial Development and Research and Development staffs of Uniroyal Chemical and by the Economic Analysis and Long Range Planning staff of Uniroyal, Inc.

Valuable suggestions and review advice were provided by Rodney L. Cummins and Clarence A. Clemons of the Federal solid waste management program.

PART I: CONTENTS

Page
SUMMARY 1
INTRODUCTION 4
ACKNOWLEDGEMENTS 5
FABRICATED RUBBER PRODUCTS INDUSTRY
  History 7
  Future Trends 8
DIVISIONS OF THE INDUSTRY
  Tires and Tire Products 8
  Canvas and Waterproof Footwear 13
  Belts 17
  Hose 17
  Sponge and Foam Rubber Products 23
  Mechanical Goods 26
  Wire and Cable 26
COST OF SOLID WASTE DISPOSAL 29
RECOMMENDATIONS 30

APPENDIX
  A - Methods and forms 30
  B - Glossary of terms 31

INDEX

TABLES

Table I-1 Summary of industry waste, 1968 3

FIGURES

Figure I-1 Concentration of the industry 2
Figure I-2 New rubber consumption, total 9
Figure I-3 New rubber consumption, % by industry groups 10
Figure I-4 Tires, manufacturing process 14
Figure I-5 Tires, number of units produced 15
Figure I-6 Tires, product weight and solid waste 16
Figure I-7 Footwear, manufacturing process 18
Figure I-8 Footwear, production by number 19
Figure I-9 Footwear, product weight and solid waste 20
Figure I-10 Belting, manufacturing process 21
Figure I-11 Belting, product weight and solid waste 22
Figure I-12 Hose, manufacturing process 24
Figure I-13 Hose, product weight and solid waste 25
Figure I-14 Sponge and foam, product weight and solid waste 27
Figure I-15 Mechanical goods, product weight and solid waste 28

Summary

SOLID WASTE MANAGEMENT IN THE FABRICATED RUBBER PRODUCTS INDUSTRY, 1968

The fabricated rubber products industry consists of those manufacturers who combine elastomeric materials, fabrics, metal products, chemicals and mineral fillers purchased from others and by suitable processing produce tens of thousands of different products for the use of consumers and industry. The largest volumes of these products are automotive tires, but they include canvas and rubber footwear, wire and cable covers, hose and belting, foam and sponge, and the great variety of molded consumer and industrial products grouped together as mechanical rubber goods. The common characteristic of the industry is that its products are based on elastomers (rubber) to the exclusion of similar products based on plastics. The industry does not include the manufacture of synthetic elastomers nor the reclaiming of rubber as these are supplying industries and not part of the fabricating industry.

In 1968 the fabricated rubber products industry produced 10.7 billion pounds of products with a shipping value in excess of 7.5 billion dollars and employed about 250,000 people. There were some 1,500 companies operating at 2,000 locations but the great majority were small specialty shops employing 10 people or less. If value of shipments is used as a measure of production, manufacturing facilities in only 10 states account for 75 percent of the output of products. These are the North Atlantic and East North Central States plus Alabama, Texas and California. Figure I-1 shows the concentration of the fabricated rubber products industry in the important states as percent of the total based on the value of shipments.

All of the 10.7 billion pounds of product will be used by consumers or industry and in a fairly limited period will be worn-out and abandoned and enter into the general solid waste mass of the country as will be discussed in Part II of this study, *Waste Rubber and Its Reuse, 1968.*

This part of the study is concerned only with the solid waste problem which (originates from the fabrication of rubber products and which) must be disposed of at the manufacturing site. It is not concerned with ultimate disposal by the consumer of the product or the product package.

In the manufacture of the 10.7 billion pounds of salable rubber products in 1968, it is estimated that 1,058 million pounds of solid wastes originated from the fabricating facilities and had to be disposed of at those locations. These solid wastes had no present value and represented a disposal cost of about $9.5 million for collection, haulage and dumping. This sum does not include the cost to the fabricator of processing these semi-finished goods, but this internal cost is a constant stimulus to the producer to keep wastes to the lowest level possible.

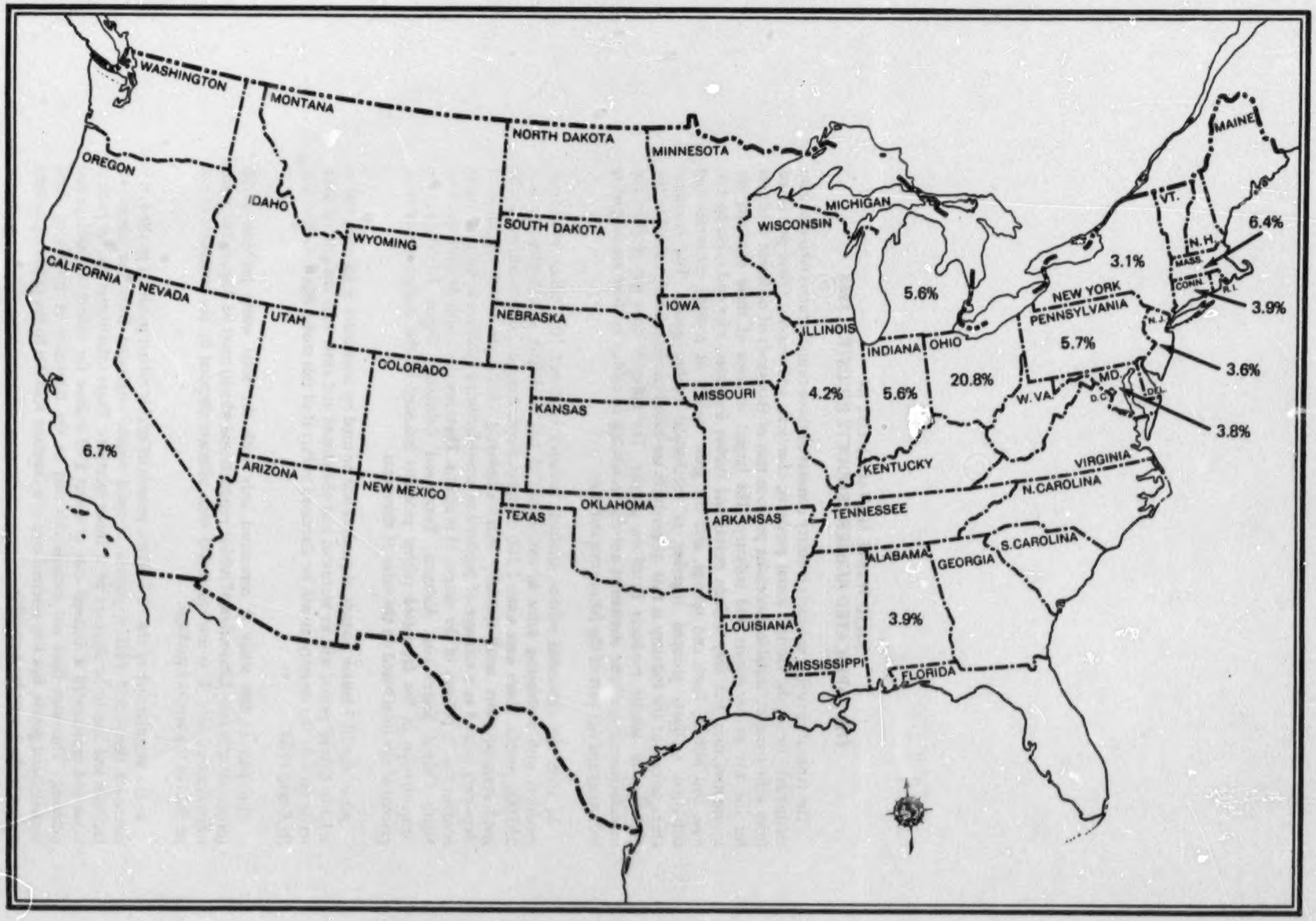

WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
OREGON
IDAHO
SOUTH DAKOTA
WYOMING
WISCONSIN
MICHIGAN
MAINE
VT.
N.H.
MASS.
CONN.
R.I.
6.4%
3.1%
3.9%
CALIFORNIA
NEVADA
UTAH
NEBRASKA
IOWA
5.6%
NEW YORK
PENNSYLVANIA
N.J.
ILLINOIS
INDIANA
OHIO
5.7%
3.6%
COLORADO
KANSAS
MISSOURI
4.2%
5.6%
20.8%
MD.
DEL.
D.C.
W. VA.
3.8%
6.7%
ARIZONA
NEW MEXICO
KENTUCKY
VIRGINIA
N.CAROLINA
TEXAS
OKLAHOMA
ARKANSAS
TENNESSEE
ALABAMA
GEORGIA
S.CAROLINA
LOUISIANA
MISSISSIPPI
3.9%
FLORIDA

FIGURE I-1 TWELVE MAJOR FABRICATED RUBBER PRODUCTS MANUFACTURING STATES BASED ON VALUE OF GOODS SHIPPED

The kinds and relative quantities of this manufacturer's solid waste will vary according to the product or products made at a particular location. The complexity of the industry has necessitated grouping the products made into six general categories and the types of waste into five categories. Table I-1 gives the estimated breakdown of fabricator's solid wastes for the entire industry in 1968. Details for each of the product categories are given later in the report as the quantity per million pounds of product as a guide to evaluation of the solid waste problem for any specific location knowing the product mix at that location.

In Table I-1, and subsequent tables in this volume, the solid waste categories include materials as follows. Paper, cardboard and wood includes all such inputs to the fabrication plant as raw material bags and wrappers, carton, non-returnable wood boxes, pallets, and shipping dunnage, machinery crates, production cards and stationery waste, and production supplies. It does not include out-bound cartons, wrappings or other packaging. Rubber compound includes in-process wastes consisting of trimmings, molding wastes, damaged stocks, quality control rejects or other combinations of rubber, pigments and chemicals which cannot be reprocessed in any way in the plant or sold to others at some value. Textiles refer to woven, knitted, nonwoven, or cord textile products, usually cotton or synthetic, which are used in fabricated rubber products and may be trimmings, short ends, damaged goods or quality rejects from any stage of processing and are of such a nature that they cannot be reprocessed in some way or sold to others for value. Metals are both ferrous and non-ferrous wires, fittings or other attachments from damaged or rejected products which cannot be recovered or sold for value and the largest part would be ferrous beadwire from pneumatic tires or ferrous inserts from moldings. The other category includes plastic wrapper film or worn-out separators, plastic and glass bottles, metal cans or drums, and miscellaneous unclassified floor sweepings and other earthy materials.

The tire and tire products segment of the industry accounts for about three-quarters of the total weight of finished products but generates only about 40 percent of the total solid waste. Because of the large volume of a single type of product, tires are generally made by semi-automated procedures in modern or modernized factories. This permits the use of bulk raw materials reducing the amount of input paper bags to be disposed of. It permits standardized assembly procedures and better waste cost control and provides the possibility of utilizing process waste in less critical products such as flaps and other tire accessories. An important part of the rubber compound waste is cure-bags which are relatively short-lived accessories to the tire curing operation and which when discarded cannot always be sent to reclaimers.

Table I-1

SOLID WASTE GENERATED BY THE FABRICATED RUBBER PRODUCTS INDUSTRY: 1968

(Millions of pounds)

Type of Waste	Type of Rubber Product						
	Tires and Tire Products	Foot-wear	Belts	Hose	Foam and Sponge	Mech. Goods	Total
Paper, cardboard, and wood	100.5	8.5	6.8	11.7	9.6	65.5	202.6
Rubber compound	89.3	45.0	10.2	19.2	54.0	140.7	358.4
Textile materials	44.2	33.0	6.3	6.3	0.1	42.8	132.7
Metals	72.7	00.5	0.6	3.6	---	21.3	98.7
Other Materials	105.2	17.5	7.6	17.2	16.2	102.0	265.7
Total Wastes	411.9	104.5	31.5	58.0	79.9	372.3	1,058.1

For the footwear segment the paper input is small because much of the raw material enters in a pre-processed condition to avoid soil. Because of the domination of hand work on a great variety of small units, the wastage in rubber compound and textile material trimmings is too high to use up entirely in lower quality components such as inner soles and counter stocks. There is a limited market for these wastes to others, but the net disposable waste is high.

For the belting, hose, and mechanical goods segments, which are usually combined in a single plant, the big waste item is rubber compound, usually in the cured state so it cannot be recycled. This segment is made up of a very large number of items largely hand-built to rigid specifications. As a result there is a sizable amount of spoilage and quality rejects which cannot be safely sold as off-grade products but must be scrapped and disposed of as solid waste.

Most foam and sponge product raw materials are received as bulk water suspensions and so the input paper is relatively small. The foam process in itself produces wastage of rubber compound as trimmings and this makes up a large part of the solid waste. Many attempts have been made to reconstitute this foam scrap into useful products but they have met with little success as they lack the special properties of new foam. The waste is not at all attractive to rubber reclaimers because of its bulkiness.

The problem of solid wastes is no novelty to the fabricated rubber products industry forced upon them by the great number of units of an endless variety that they must produce to rigid specification by largely hand assembly methods. Rubber industry management is well aware of the internal cost of producing solid waste. This cost is reflected in high reject rates, wasted raw material, and most of all, wasted labor, a high price commodity. Short of further automation and other capital investment, there is little likelihood that production wastes can be reduced further in the near future.

Most top management is not aware of the actual cost of solid waste disposal which includes in-plant collection and baling, and outside hauling and dump fees or investments. In many cases only lower management levels are aware of the actual disposal costs. Several plants have salvage operations which sell all the waste they can and hope that this revenue will offset part or all of the solid waste disposal costs.

Certainly more careful segregation of waste by kind would make disposal more effective and possibly reduce the total amount by allowing more rework. Powder spillage and trim scrap could be kept out of general waste and returned to process. Reworking of plastic separator sheets was reported by one major company, cutting that particular waste item to one-sixth of what it was. Such investments for reprocessing can reduce the disposal costs and amounts of solid waste to be disposed.

The segregation of solid waste will allow for the incineration of the non-rubber portion which accounts for sixty-percent of the material now being disposed of in land fill sites. Present techniques waste valuable land fill sites by discarding many non-contaminating combustibles in them. Further, incinerator technology should be developed that will enable industry or municipality to burn rubber products without polluting the atmosphere and thus eliminate much of the need for land fill operations in or near our crowded metropolitan areas. Incineration is a short term solution to the problem. Ultimately reuse and recycle are the long term solutions to the total solid waste problem.

Introduction

The Solid Waste Disposal Act (Pl 89-272) enacted by the Congress of the United States in October 1965, authorized the Department of Health, Education, and Welfare to initiate a program of research and development in solid wastes management. The Act also authorized assistance to states, local governments, and interstate agencies as well as to private agencies, groups, and individuals in solving solid waste disposal problems in order to alleviate this serious national problem. In order to efficiently perform responsibilities under this Act, it is necessary that accurate basic information be made available on the kinds, quantities, distribution and potential economic disposal of the solid wastes generated by specific industries.

This study was performed with the generous cooperation of the fabricated rubber products industry in order to evaluate the solid waste problems in the operation of this specific industry. It is intended as a guide for all concerned with solid waste utilization and disposal and it is hoped that it will be of assistance to the industry itself in its continuing efforts to control the problem.

The study was conducted during the period July 1, 1968 to July 1, 1969 and specifically covers the situation for the calendar year 1968 with historical backgrounds and best estimates of the future through 1973. The information was obtained through personal interviews as described in Appendix A, Study Methods, of this report.

Since many of the terms used may be unfamiliar outside of the rubber industry, the less obvious ones are defined in Appendix B, Glossary, of this report.

Acknowledgments

A study such as the present one which encompasses the whole of a large and diversified industry would not have been possible without the generous cooperation of many knowledgeable individuals in that industry. We wish to express our thanks for the assistance of the personnel of the following companies, associations, and institutes.

Acme Hamilton Manufacturing Corp.
Trenton, New Jersey

Acushnet Co.
New Bedford, Mass.

Aldan Rubber Co.
Philadelphia, Pa.

Alliance Rubber Co.
Alliance, Ohio

Amerace Corp.
Butler, New Jersey

Ames Rubber Corp.
Hamburg, New Jersey

Armstrong Rubber Co.
West Haven, Conn.

Ashland Rubber Products Corp.
Ashland, Ohio

A. Baker Manufacturing Co., Inc.
South Bend, Ind.

Barr Rubber Products
Sandusky, Ohio

Brunswick Rubber Co.
New Brunswick, N. J.

Burke Rubber Co.
San Jose, Cal.

Burton Rubber Processing
Burton, Ohio

H. O. Canfield, Inc.
Clifton Forge, Va.

Carlisle Tire & Rubber Division
Carlisle, Pa.

Carol Wire & Cable Corp.
Pawtucket, R. I.

Cat's Paw Rubber Co.
Baltimore, Md.

Centrex Corp.
Findlay, Ohio

Chemical Rubber Products, Inc.
Beacon, N. Y.

Comar Products, Inc.
Butler, N. J.

Bata Shoe Co.
Belcamp, Md.

Beebe Rubber Co.
Nashua, N. H.

Bishop Manufacturing Co.
Cedar Grove, N. J.

Boston Woven Hose & Rubber
Cambridge, Mass.

Cooper Tire & Rubber Co.
Findlay, Ohio

Davol Rubber Co.
Providence, R. I.

De Laval Separator Co.
Poughkeepsie, N. Y.

Dunlop Tire & Rubber Corp.
Buffalo, N. Y.

Electric Hose & Rubber Co.
Wilmington, Del.

Faultless Rubber Co.
Ashland, Ohio

Firestone Tire & Rubber Co.
Akron, Ohio

Garlock, Inc.
Palmyra, N. Y.

Gates Rubber Co.
Denver, Colo.

Globe Manufacturing
Fall River, Mass.

Goodall Rubber Co.
Trenton, N. J.

B. F. Goodrich Co.
Akron, Ohio

Goodyear Tire & Rubber Co.
Akron, Ohio

Graflo Rubber Co.
Radford, Va.

Griswold Rubber Co.
Moosup, Conn.

Hewitt-Robins Inc.
Buffalo, N. Y.

I T T Wire & Cable Division
Pawtucket, R. I.

Collette Manufacturing Co.
Amsterdam, N. Y.

Continental Rubber Works
Erie, Pa.

Converse Rubber Corp.
Malden, Mass.

Cooke Color & Chemical Co.
Hackettstown, N. J.

Lord Manufacturing Co.
Erie, Pa.

Lovell Manufacturing Co.
Erie, Pa.

Manhattan Rubber
Passaic, N. J.

Mansfield Tire & Rubber Co.
Mansfield, Ohio

Master Processing Corp.
Lynwood, Cal.

Midwest Rubber Reclaiming
East St. Louis, Ill.

Monarch Rubber Co.
Baltimore, Md.

National Hose Co.
Dover, N. J.

Nearpara Rubber Co.
Trenton, N. J.

Oliver Tire & Rubber Co.
Oakland, Cal.

Pawling Rubber
Pawling, N. Y.

Permacel
New Brunswick, N. J.

Perry Rubber Co.
Massillon, Ohio

H. K. Porter Co.
Pittsburgh, Pa.

Republic Rubber
Youngstown, Ohio

Rome Cable
Rome, New York

Schenuit Rubber Co.
Baltimore, Md.

Kirkhill Rubber Co.
Brea, Cal.

A Larkin & Son
Chicago, Ill.

Laurie Rubber Reclaiming
New Brunswick, N. J.

Los Angeles Standard Rubber
Los Angeles, Cal.

Uniroyal, Inc.
New York, N. Y.

U. S. Rubber Reclaiming
Vicksburg, Miss.

Victor Balata & Textile Belting Co.
Easton, Pa.

Vogt Manufacturing Co.
Rochester, N. Y.

A Schulman, Inc.
Chicago, Ill.

Swan Rubber Co.
Bucyrus, Ohio

Taylor Bros. Co.
Cleveland, Ohio

Thompson Aircraft Tire
San Francisco, Cal.

W. J. Voit Rubber Co.
Santa Ana, Cal.

Vulcanized Rubber & Plastics Co.
Morrisville, Pa.

West American Rubber Co.
Orange, Cal.

Xylos Rubber Co.
Akron, Ohio

Associations

The Asphalt Institute
College Park, Md.

The National Tire Dealers and Retreaders Association, Inc.
Washington, D.C.

Rubber Manufacturers Association
New York, N. Y.

The Rubber Reclaimers Association, Inc.
New York, N. Y.

HISTORY OF THE FABRICATED RUBBER PRODUCTS INDUSTRY

The term "rubber" is one of those unfortunate English language expressions which has taken on many imprecise and only vaguely related meanings. It is said that when the native material first appeared it was first used for "rubbing" (erasing) and so gained its name. The word now refers to the natural vegetable product in its various forms, to synthetic materials of a similar nature, to compositions based on such materials, to finished products generally, and to specific kinds of finished products. Foreign languages have different terms for these different things but we must suffer the confusion of a single term.

Rubber was first brought to Europe by the early explorers of the tropics where it had been used by the natives since ancient times to make slippers, balls, bottles, toys and dolls. Natural rubber is the product of a wide variety of unrelated tropical trees, shrubs and vines, occurring as a watery dispersion (latex) in a separate system of channels and tubes. It apparently functions as a reserve food supply and as a protective material for the growing plant from which it is gathered by controlled cutting or injury.

Until about 1920, the rubber of commerce was almost entirely the variable product of primitive gathering from wild plants in Equatorial Africa and South America. After many years of development, in the 1920's uniformly high quality natural rubber from carefully managed plantations in the Far East came on the market in sufficient quantity to quickly replace the inferior wild rubbers. Because of wildly fluctuating prices and uncertain supply, the rubber and chemical industries were stimulated to develop synthetic substitutes. In the 1930's the first truly useful synthetic rubbers became commercial on a limited scale. In 1942 under wartime stress, a crash program by the federal government cooperating with private industry established the first large scale general purpose synthetic rubber plants to produce the famous GR-S. In the past 25 years, one new synthetic rubber after another has become commercial each with its own specific value to the fabricator.

Practical rubber technology was developed in a limited way in the first half of the nineteenth century by such men as Macintosh and Hancock in England and Goodyear in the United States. At first the products were of limited usefulness. Although they had the unique property of being waterproof, the rainwear, which was the principal product, was intolerably sticky in warm weather and too stiff to wear in cold weather. Modest improvements were made by vapor or liquid treatment of the rubber surface in various processes.

In 1839 Charles Goodyear discovered that if rubber products containing flowers of sulphur were exposed to heat they developed acceptable properties. This was the discovery that firmly established the fabricated rubber products industry. Soon a multitude of small plants in New England and elsewhere were producing footwear, boots, rainwear, medical sundries, hard rubber and simple mechanical items. The Civil War not only proved the value of these new manufactures but made them familiar to soldiers and civilians from all parts of the expanding country.

By 1900 the bicycle craze, rubber tired carriage wheels and the beginnings of the automotive industry opened up the tire market on a large scale. World War I military needs proved the value of truck and bus transportation of goods and people and made the first important pneumatic tire market. Rubber was now big business and could support and encourage industrial and university research in the raw materials, chemical additives, processes, and equipment by many skilled scientists who changed a trial-and-error industry into a highly sophisticated technology. It was none too soon for service conditions were changing rapidly. Expected tire mileage was going up while tire loading and average road speed was steadily increasing. Rubber technology was under constant pressure to convert a relatively fragile composition into engineered products capable of performing reliably under extremely severe conditions.

FUTURE OF THE FABRICATED RUBBER PRODUCTS INDUSTRY

The rubber products industry will enter the 1970's with a half century of sophisticated technology, a wealth of new rubbers, fibers, and other raw materials to utilize, and with major new engineering and design improvements to apply. The problem will be to maintain reasonable prices, service life, reliability and increasing output in the face of increasingly severe performance requirements without aggravating the inevitable solid waste problem of discarded rubber products.

Because of the variety and complexity of the products of the fabricated rubber products industry, it is necessary to evaluate the industry size and growth by the amount of natural and synthetic rubber polymer which is consumed, which is reliably reported. The annual per capita consumption of rubber polymer in the United States has increased from a negligible amount in 1900 to seven pounds per capita in 1930 and to thirty pounds per capita in 1968.

In Figure I-2 the total consumption of rubber polymer is traced from 1958 to the present and projected to 1973. Growth was mildly erratic over the past ten year period but averaged 5.4 percent per year. The projections through 1973 are a consensus of the industry and show a growth rate of about 4.3 percent per year. It is a realistic assumption that the product mix of the industry has not materially changed in the past ten years and will not change in the immediate future, and that the relative waste output has and will remain nearly the same for this mature cost conscious industry. In order to quantify the solid waste problem directly from the fabricated rubber products industry, we have presented in the right hand margin a scale of solid waste in billions of pounds from which the weight in any given year can be estimated.

The anticipated growth changes for the different segments of this industry are discussed in detail in the following specific sections.

Consumption of new rubber by the industry is reported in three parts; tires and tire products, and other products. The categories are not very helpful in detail, but the data does illustrate the very dominant position of tires and tire products. Figure I-3 presents this information from 1958 to 1969 and forecast through 1973 as a percent of total new rubber consumption. Tire and tire products consistently use 62 to 66 percent of all new rubber. Wire and cable use a small part of the total which has remained constant in absolute terms but has declined from three to one percent of the total. The catch-all "other products" uses about a third of the rubber in a great variety of items. Obviously the industry does not anticipate any major shift in product mix.

In the following sections of the report, trends and special conditions in various segments of the overall fabricated rubber products industry are discussed in detail. In these sections the solid waste generated by the operation of typical plants is given in terms of ratio to output, specifically the average weight of solid waste to be disposed of per million pounds of product produced. This should not only be of value to waste control authorities in evaluating their problems, but it is hoped will be of value to industry management in improving their own plant performance.

TIRES AND TIRE PRODUCTS

The tire and tire products industry consists of those manufacturing facilities comprised in the following Standard Industrial Classification (1967 Manual) categories.

30111/30112/30113-11,-13,-15,-17

All pneumatic tire casings including passenger, truck and bus, aircraft, motorcycle and scooter, bicycle, off-the-highway, farm implement, tractor, and industrial types.

30113-33,-35,-41,-51

All solid and semi-pneumatic tires for industrial and highway use, for wheeled toys, baby carriages, bogies, and idler and support rollers.

30114

All inner tubes for pneumatic tires.

30115

All tread rubber for tire retreading slab stock for further processing, flaps, repair materials, and associated products.

This segment produces 70 percent of finished product weight of the entire fabricated rubber products industry and six major companies produce 83 percent of the tires at 42 locations. Ten other companies produce the remaining 17 percent at 15 locations. Usually inner tubes are produced in plants separate from the tire casing plant and some tread stock for retreading is produced in detached small facilities. In general all other solid tires and auxiliary materials are made in the larger plants which produce tire casings. Passenger car tire sizes account for 65 percent by weight and 80 percent by number of all tires manufactured in the United States.

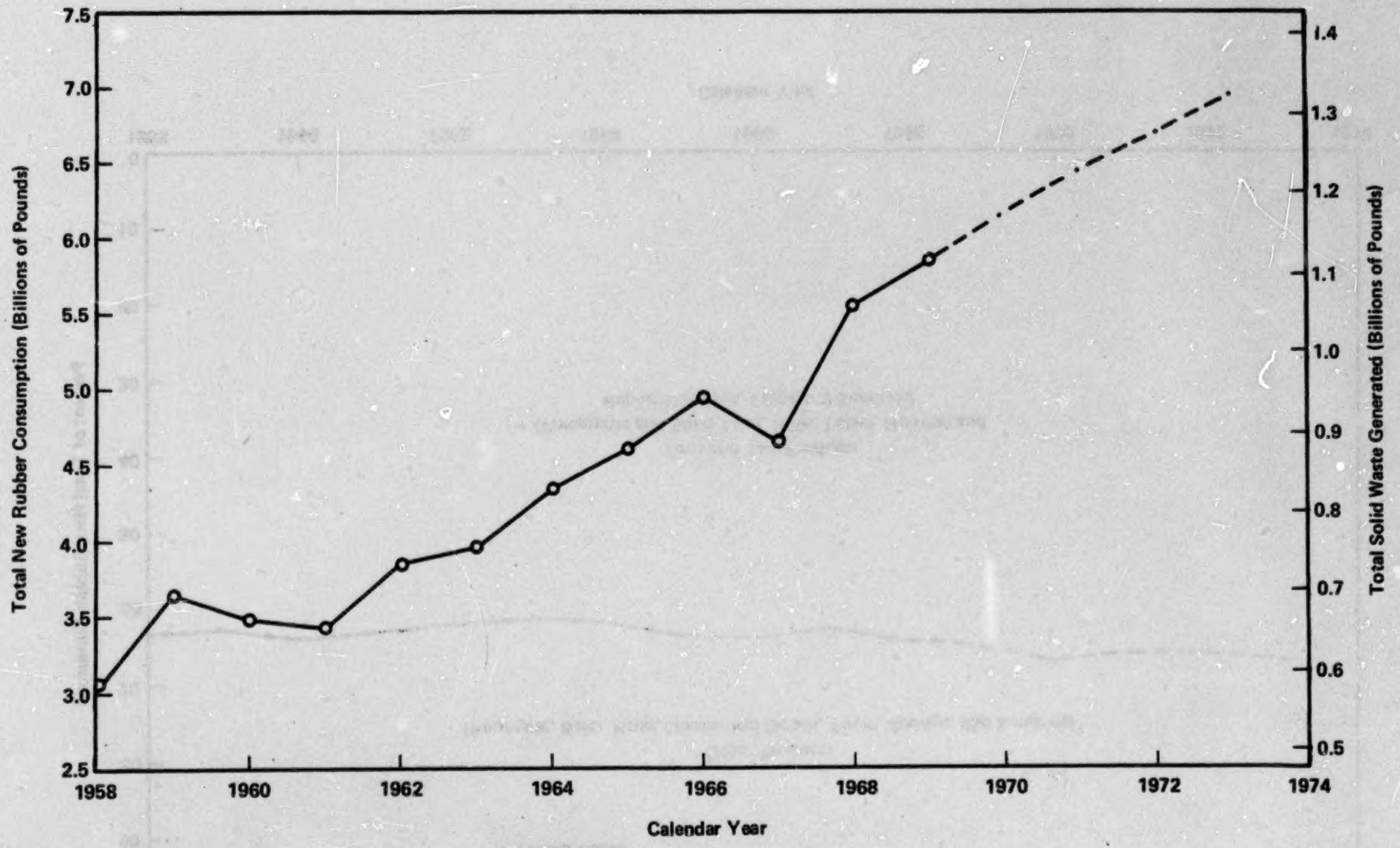


FIGURE I-2. TOTAL NEW RUBBER CONSUMPTION AND SOLID WASTE GENERATION IN THE FABRICATED RUBBER PRODUCTS INDUSTRY

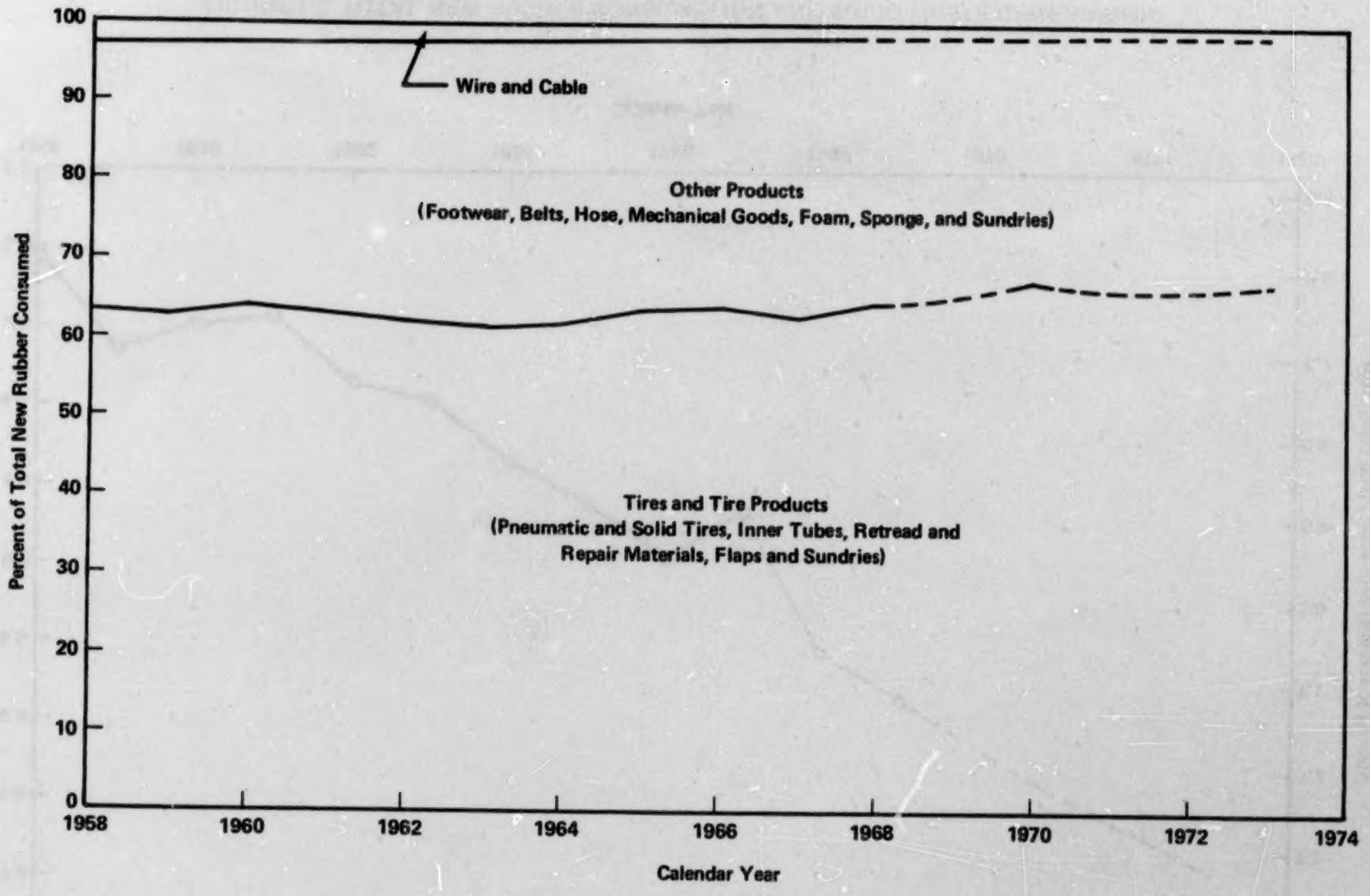


FIGURE I-3. PERCENT OF TOTAL NEW RUBBER CONSUMED

DISTRIBUTION OF TIRE PRODUCING PLANTS IN THE UNITED STATES AS OF YEAR-END 1968*

Company	Location	Units/ Day
Armstrong	DesMoines, Ia.	20,500
	Hanford, Cal.	10,500
	Natchez, Miss.	18,000
	W. Haven, Conn.	15,000
Cooper	Findlay, Ohio	13,000
	Texarkana, Tex.	11,500
Firestone	Akron, O.	27,000
	Albany, Ga.	17,000
	Barberton, O.	8,500
	Bloomington, Ill.	50
	Dayton, O.	20,700
	Decatur, Ill.	22,000
	DesMoines, Ia.	22,000
	Los Angeles, Cal.	15,500
	Memphis, Tenn.	28,000
	Pottstown, Pa.	30,000
	Salinas, Cal.	15,000
Gates	Denver, Colo.	18,200
	Nashville, Tenn.	12,000
General	Akron, O.	9,050
	Bryan, O.	30
	Charlotte, N.C.	11,000
	Mayfield, Ky.	19,800
	Waco, Tex.	16,000
Goodrich	Akron, O.	6,000
	Ft. Wayne, Ind.	18,000
	Los Angeles, Cal.	11,500
	Oaks, Pa.	19,000
	Tuscaloosa, Ala.	21,000
Goodyear	Akron, O.	38,000
	Conshohocken, Pa.	13,500
	Cumberland, Md.	20,500
	Danville, Va.	5,500
	Freeport, Ill.	14,000
	Gadsden, Ala.	44,000
	Jackson, Mich.	30,000
	Los Angeles, Cal.	18,000
	Topeka, Kans.	30,000
	Tyler, Tex.	15,000
	Union City, Tenn.	17,500
Mansfield	Mansfield, O.	14,000
	Tupelo, Miss.	10,000
Mohawk	Akron, O.	6,000
	Salem, W. Va.	4,700
	W. Helena, Ark.	10,000
Uniroyal	Chicopee Falls, Mass.	28,000
	Detroit, Mich.	33,700
	Eau Claire, Wis.	31,000
	Los Angeles, Cal.	16,500
	Opelika, Ala.	13,500
Carlisle	Carlisle, Pa.	
Corduroy	Grand Rapids, Mich.	
Denman	Warren, O.	
		58,800
Dunlop	Buffalo, N.Y.	
McCreary	Indiana, Pa.	
Schenuit	Baltimore, Md.	

*Rubber World Vol. 159 No. 4 page 31, Jan. 1969.

This study was intended to reliably sample the entire tire and products industry by direct interview as may be judged from the following table.

MAJOR PRODUCERS

	Corp.	Plants
Industry	6	42
This Study	5	

MINOR PRODUCERS

	Corp.	Plants
Industry	10	15
This Study	6	

% OF CAPACITY

	Major	Minor
Industry	85	15
This Study	65	10

Table I shows the capacity of all tire producing facilities in the United States as of the end of 1968 and their geographical distribution as publicly reported.

The amount of solid waste generated in the manufacture of one million pounds of tires and tire products is shown below. These are average values for 1968 but because of the similarity of operation from plant to plant, they are representative of most operations in this category. There is little reason to believe that the situation was much different in the past ten years and no major improvement is to be expected in the next few years because this wastage has been recognized as a serious manufacturing cost for many years and is under constant attack. The total wastes amount to about 5.5 percent of the total weight of product made. One million pounds of tire industry product is equivalent to 40,000 passenger tire casings.

Type of solid waste	Pounds of waste per million pounds of product shipped
Paper, cardboard and wood	13,400
Rubber compound	11,900
Textile material	5,900
Metal	9,700
Other	14,000
Total Waste	54,900

The paper, cardboard and wood input waste is largely paper bags in which carbon black, mineral pigments, and chemicals are received. These are of little value for reuse in the paper industry because of severe contamination by the powders they contained. At least in the larger facilities carbon black is now received in dustless bulk shipments in cars or large returnable containers so the raw material bags for this item are eliminated. There is a sizable amount of in-process paper and wood waste from separator paper, temporary wrappings, and card and paper stock used to identify and control in-process materials. All of this paper and wood waste could be handled in suitable incinerators if properly segregated. At present in most cases no attempt is made at segregation, proper incinerators are not available, and the solid waste is handled by general collection, baling or semicompression, and hauling to dumps.

The rubber compound waste includes solids containing appreciable amounts of rubber which makes them unsuitable for combustion in any ordinarily satisfactory incinerator. Not only is the rubber hydrocarbon content such that it burns with an obnoxiously sooty flame, but the gases contain a large concentration of acid and sulfurous gases. The waste is made up of in-process trimmings and molding waste, in-process spoiled stock, curing bags, quality rejects and experimental and test products.

Some of the in-process waste is used up within the plant itself or related operations as raw material in low quality goods such as flaps and light service solid tires and rollers, but this means of disposal is limited by the product mix. Curing bags are a tire-like structure of rubber with some fabric which is inserted in the tire when it is cured to exert internal pressure. For passenger tires, these units weigh 12 pounds apiece and will serve to cure 250 to 300 tires before they must be scrapped. It is estimated that 7 to 8 million pounds of these bags are scrapped each year, but since they can be handled by reclaimers with some difficulty only a part of the curing bags appear in the solid waste figures above.

Finished tire rejects for quality reasons average one percent for passenger tires and less than one percent for heavier duty tires. In addition, there is a fraction of one percent of finished tires which are partially or completely destroyed in testing in the laboratory, on tracks, or in road tests. These cannot be sold as off-quality goods and they are not readily disposed of for reclaiming as new tires are much more difficult to process than are service-aged tires which have undergone desirable physical changes. All of these new unsalable tires are included in the waste numbers above, broken down into their known components.

Textile fabric and tire cord scrap (ends, clippings, defects) which have not been rubberized find a ready market with scrap dealers. Even the uncured tire carcass scrap (trimmings and spoilage) which is 60 percent rubber compound and 40 percent textile material usually can be sold to scrap dealers for resale to the mechanical rubber goods industry. Most of the amount under textile materials would be the textile content of finished goods which cannot be sold.

The metal waste at present is largely the high carbon steel wire from the tire bead. This consists of defective material, in-process waste, trimmings and the wire component from finished good rejects. There is some wastage of metal inner tube valves but this material finds a ready resale as scrap metal and does not appear in the above figures. At one time scrap bead wire could be compressed, baled and sold as scrap steel for use in the steel industry but it was never too desirable because of its bulkiness and of recent years has found no market at all because of changing steel production technology.

Changing tire construction designs may lead to changes in both the quantity and kind of waste from the industry in the future. The changes probably will not have too much effect through 1973 but may be quite important thereafter. Most of the pneumatic tires made through 1968 were of the conventional bias construction in which the carcass was built of diagonal layers of tire cord made of conventional cotton or man-made fibers. In 1969, large numbers of belted bias tires were made in which the carcass is reinforced with circumferential belts of cords of glass fiber, synthetic fiber or even fine steel wire. It is estimated that these tires will give 15 to 40 percent more service life but they will weigh about 18 percent more than the conventional bias tire. There is no reason to believe that the net solid waste ratio will change materially and although fewer units may be marketed the weight of product will remain the same. The only change should be that there will be glass fiber in the scrap which will make it less attractive for resale and more difficult to handle in incinerators.

Another type of construction may be an important market factor by 1973 or later. This is the radial tire in which the cords lie in radial planes which is believed to give better service. These tires are being built in limited quantities at present and because of production difficulties the rejection rates are reported to be three to five times those for conventional constructions. Before this construction becomes commercially feasible, this difficulty must be overcome but there may be some net increase in waste production. In Europe where these tires are already very popular, many of them are made with steel wire in the carcass or in the belt, in addition to the conventional wire bead. If this becomes popular in the United States, it will make even more difficult the problem of selling scrap or disposing of wastes.

In Figure I-4 a schematic outline of the tire manufacturing process is given to show the possible origin of the various types of scrap which will end up as solid waste if it cannot be reused internally or sold for some value. Figures I-5 and I-6 show the historical growth of the tire industry by the two major types along with industry consensus as to future growth through 1973. Figure I-5 presents this growth in terms of unit casings, Figure I-6 in terms of weight of product shipped and weight of solid waste to be disposed of. At one time tire manufacture was dominated by original equipment sales for new vehicles but road mileage of the national fleet has built up so high that tire demand is more nearly related to gasoline sales than to new car production. Also it will be seen that non-passenger tire markets are now growing more rapidly than passenger tire markets. Highway and air transport of goods and people is expanding, farms are using more mechanical equipment which requires pneumatic tires, and construction is moving over to massive pneumatic tired equipment. Not only are the relative number of units increasing, but the relative weight of non-passenger tires is increasing still more rapidly. Passenger tires averaged 22 pounds in 1968, truck and bus tires averaged 75 pounds, and some specialty tires for off-the-road service weigh hundreds of pounds. No substitute for the pneumatic tire would seem feasible in the immediate future. Even air-effect vehicles are said to use up more rubber in their skirts than they would on pneumatic wheels, and their wide acceptance does not seem imminent.

Inner tubes are somewhat different from tire casings in the waste problem generated. They contain very little textile material or metal and are nearly straight rubber compound. The waste is almost entirely paper input from raw materials and in-process trimmings. Inner tube scrap and rejects find a ready market with scrap dealers because they are clean compound and made exclusively from butyl or natural rubber which is very desirable to reclaimers. Scrap valves find a ready market on the metal scrap market. It was not possible to obtain waste data on inner tube production alone so the information is included in that for tires and tire products. Very few inner tubes are now used in passenger tires and then only in special cases such as wire wheel mountings. In 1968, at least 80 percent of truck, bus and heavier tires were operated with inner tubes because of the severe service. Heavy duty tubeless tires are made but the current consensus in the industry is that they will not be a major factor by 1973, if ever.

Tread rubber and repair materials generate little if any waste as they are uncured materials and can usually be reworked. It is estimated that some 20 million pounds of raw material packaging paper must be disposed of and that is included in the tire and tire products total. Tire flaps and sundries generate practically no waste and in fact are a primary means of using up in-process scrap from other tire operations.

RUBBER FOOTWEAR

The rubber footwear industry can be conveniently divided into two parts, following the S.I.C. categories.

30210-11,-13,-15 Canvas Footwear

All footwear made of canvas and rubber including high- and low-cut leisure, sports, and professional. They have textile fabric uppers with rubber soles, heels, and trim.

30210-21,-31,-41,-51 Waterproof Footwear

All protective footwear made largely of rubber, combined with fabric, leather, metal, and other materials. It includes boots and waders, laced boots, buckled and zippered arctics and gaiters of both utility and style grades, and light and heavy pull-on shoe covers.

This report excludes all consideration of the above types of footwear which are made of plastic materials in place of rubber, but which are sometimes made in the same plant. Separate rubber soles and heels or cured rubber slabs from which they may be cut are excluded here as they are classified under mechanical goods as described later.

In 1968 the canvas and waterproof footwear industry produced 500 million pounds of finished product, or 190 million pairs of canvas footwear and 30 million pairs of waterproof footwear.

The coverage of this study's interviews was as follows:

MAJOR

	Corp.	Plants
Industry	8	12
This Study	4	7

MINOR

	Corp.	Plants
Industry	38	more than 40
This Study	0	0

	Percent coverage of industry, this report
Industry	
This Study	40

The amount of solid waste generated is shown below. It was not possible to make a distinction between that of the canvas and of the waterproof type as they are made in the same plants.

Type of solid waste	Pounds of waste per million pounds of product shipped
Paper, cardboard and wood	17,000
Rubber compound	90,000
Textile material	66,000
Metal	1,000
Other	35,000
Total Waste	209,000

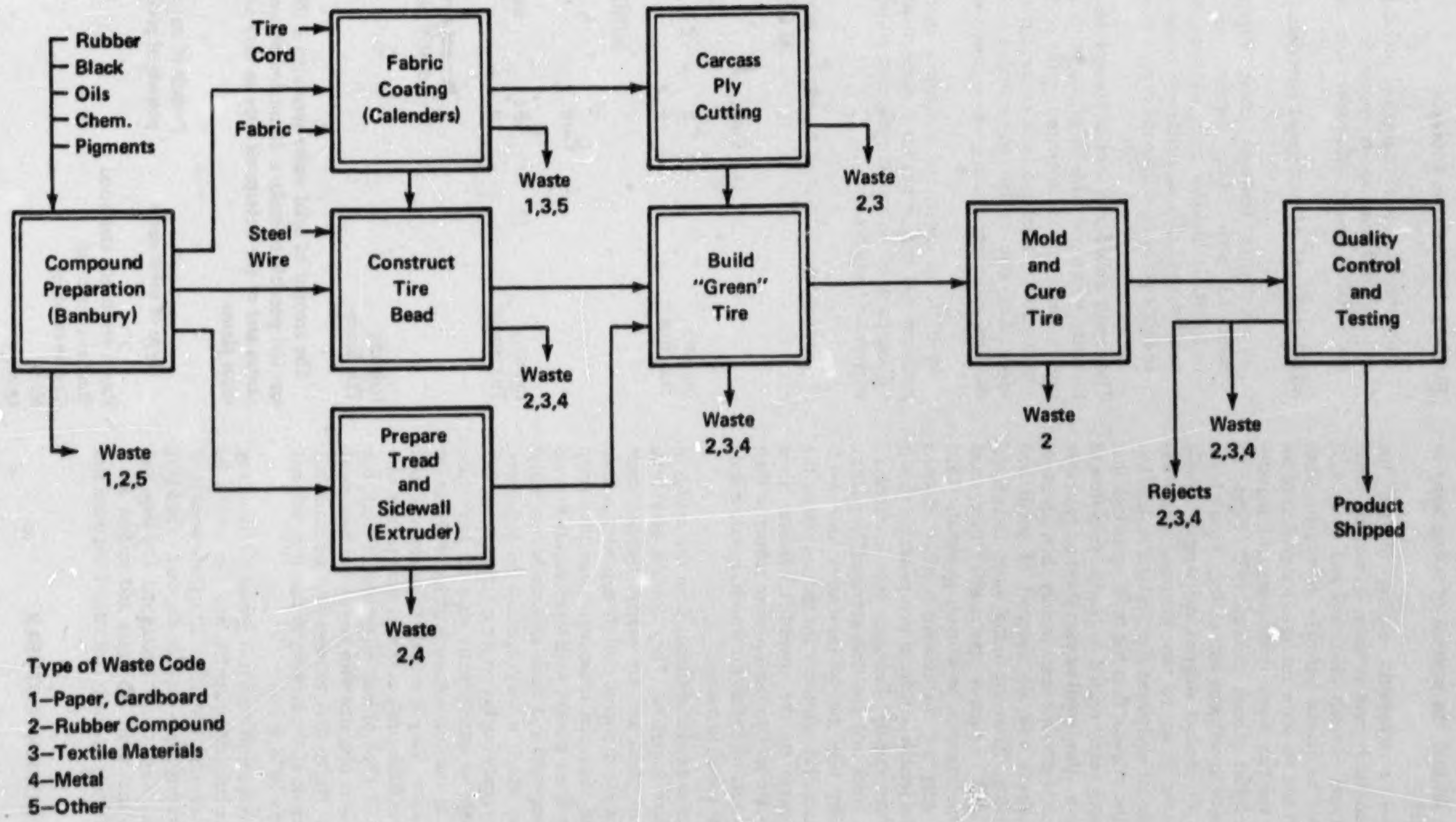

Rubber
Black
Oils
Chem.
Pigments
Compound Preparation (Banbury)
Waste 1,2,5
Tire Cord
Fabric
Fabric Coating (Calenders)
Waste 1,3,5
Steel Wire
Construct Tire Bead
Waste 2,3,4
Prepare Tread and Sidewall (Extruder)
Waste 2,4
Carcass Ply Cutting
Waste 2,3
Build "Green" Tire
Waste 2,3,4
Mold and Cure Tire
Waste 2
Quality Control and Testing
Rejects 2,3,4
Waste 2,3,4
Product Shipped
Type of Waste Code
1—Paper, Cardboard
2—Rubber Compound
3—Textile Materials
4—Metal
5—Other

FIGURE I-4 SCHEMATIC DIAGRAM OF TIRE MANUFACTURING PROCESS

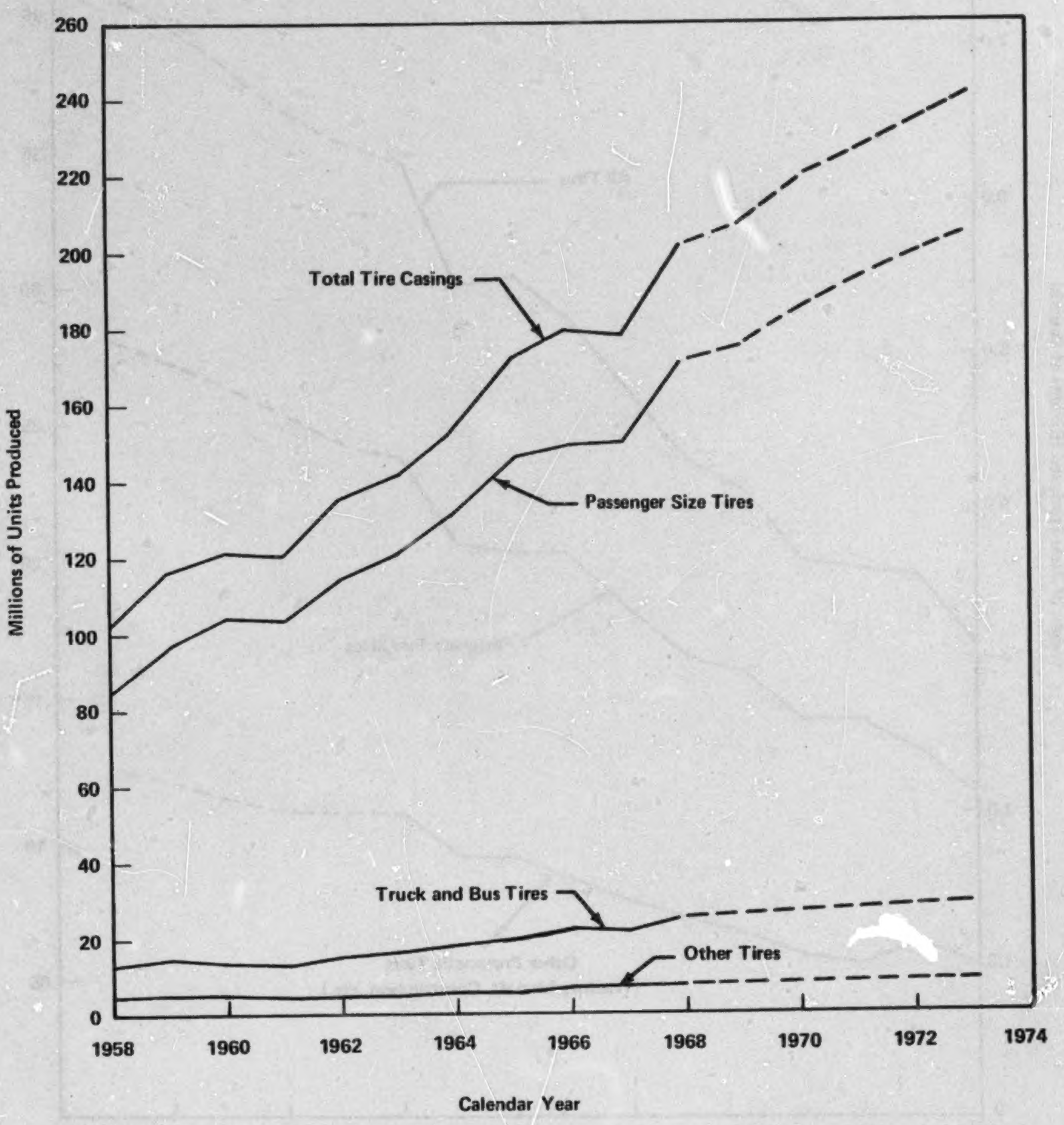


FIGURE I-5 NUMBER OF AUTOMOTIVE TIRES PRODUCED

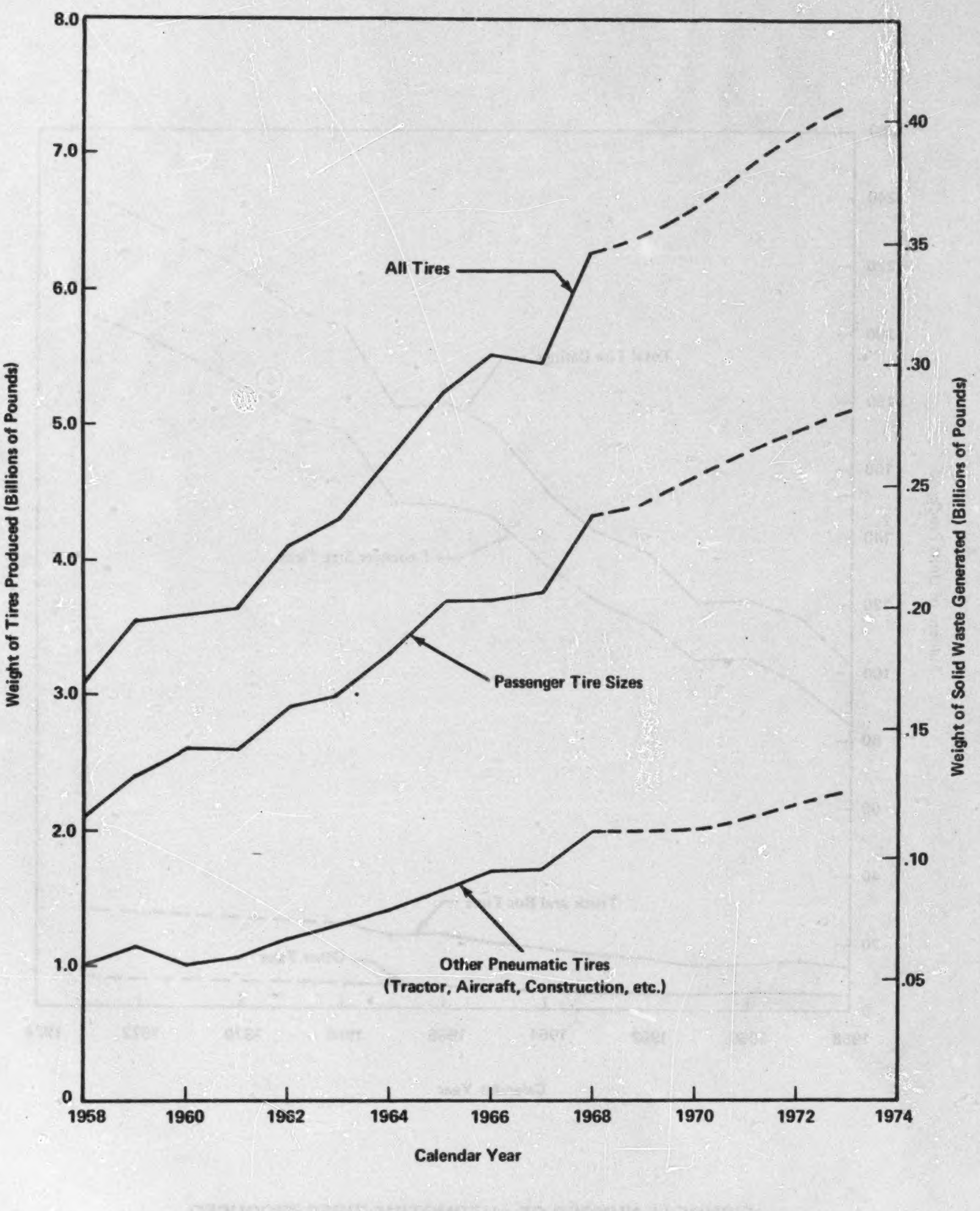


FIGURE I-6 PRODUCT WEIGHT OF TIRES PRODUCED AND SOLID WASTE GENERATED IN THEIR PRODUCTION

The paper waste is comparable to that for tires but little of the raw materials can be received in bulk because of the danger of soiling the product with loose dust. Metal waste is small because few small metal parts are now used, mostly of the zipper type. The rubber compound and textile material scrap is high because the industry produces small units by hand–assembled in a multitude of sizes and styles. Both before and after combining with rubber, a great variety of small pieces must be cut from sheet goods leaving unavoidable waste trimmings. In the compression molding process now common an excess of rubber compound is used which appears as molding waste. Sponge innersoles contribute considerable scrap because of the odd shapes and sizes to which they must be cut. The trend to injection molding in place of compression molding for attaching soles to uppers will reduce the molding waste as the rubber compound quantity can be more accurately fixed.

Some of the rubber and textile waste is ground up and used in hidden parts of footwear. The remainder has no value on the market and must be discarded.

The waterproof footwear industry has declined sharply and the canvas footwear industry has begun to decline slightly because of the competition of imports. Because of the hand work involved lower labor costs off-shore make lower prices possible. The quality is said to be lower but perfectly adequate for the American consumer who is more style conscious than ten years ago and less concerned with durability. Imports account for 10 to 15 percent of the canvas footwear domestic market and 20 to 25 percent of the waterproof market, or a total of about 72 million pounds of imported product.

In Figure I-7 is given a schematic outline of rubber footwear manufacture with the sources of the various kinds of waste. Most production rejects are repaired and sold as seconds and thirds. Rejects that must be scrapped are reported to be less than 0.1 percent of production including those destroyed in testing. Figure I-8 illustrates the history and probable future of the domestic industry in millions of pairs produced. Figure I-9 does the same for product weight and the estimated solid waste generated in operations.

BELTS

The belts and belting portion of the fabricated rubber products industry is comprised in the S.I.C. classification 30691. This includes flat belting for conveying materials and for power transmission, V-belts for automotive, appliance and industrial power use, and a wide variety of belts for toys, business machines, instruments and other devices. They vary in size from complete belts weighing as little as two ounces up to mining conveyor belts weighing up to 12 pounds per linear foot. Belts are generally built of heavy textile fabrics or cord combined with cured rubber compounds but they may include metal wire or cables. This study covered what is estimated to be 85 percent of the production of the belting industry as follows:

MAJOR

	Corp.	**Plants**
Industry	7	14
This Survey	6	9

MINOR

	Corp.	**Plants**
Industry	47	47
This survey	3	3

The solid waste generated per million pounds of belt produced is as follows:

Type of waste	**Pounds per million pounds of Products**
Paper, cardboard and wood	27,300
Rubber compound	41,000
Textile material	25,200
Metal	2,300
Other	30,200
Total Waste	126,000

Raw materials are almost all received in paper bags or cardboard containers. Rubber compound and textile waste is higher than for tires because less standardization and automation is possible, but is much less than for footwear because design is simpler and there is less variety. This waste is largely cured and uncured trimmings and very little of it can be reused in the same plant. The metal scrap is ends and damaged material from those types of belts which use metal reinforcement. The other waste is spilled pigments and earth materials which get mingled in general floor sweepings.

Belts which have minor defects are repaired in the plant and sold as first quality product. Flat belts are made in semi-continuous lengths and major defects can be cut out and the remainder sold as short lengths of first quality material. Splicing of lengths is also possible as they are usually spliced on the job in any case.

A block diagram for belt processing is given in Figure I-10 and past and estimated future belt production by weight of product and estimated weight of solid waste generated is shown in Figure I-11. The belt industry is showing a steady growth supported as it is by the steady growth of the automotive and appliance industry and by the strong trend toward bulk movement of minerals, grain, chemicals, industrial products, and people.

HOSE

The rubber hose segment of the fabricated rubber products industry is comprised in S.I.C. 30692 and is made

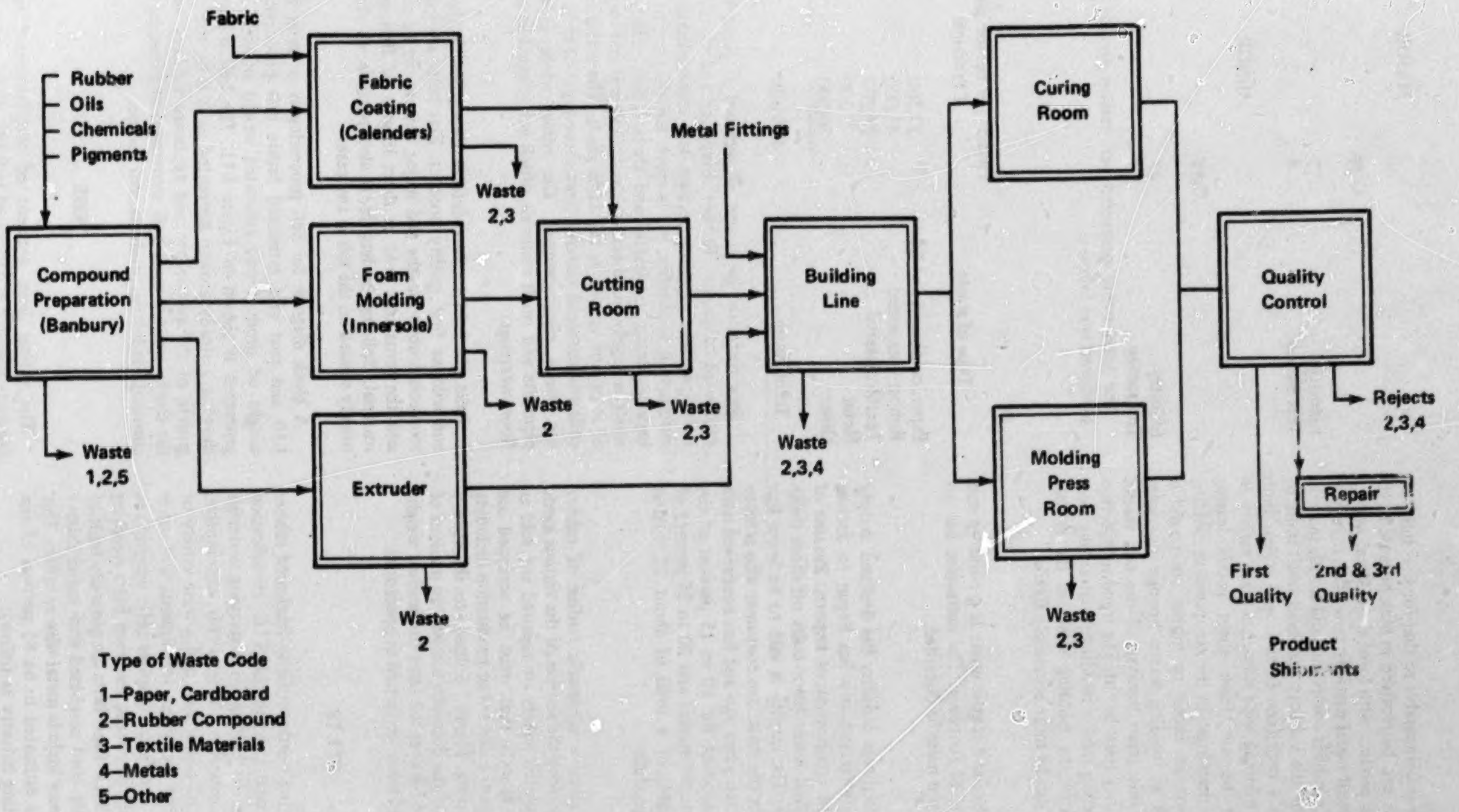

Fabric
Rubber
Oils
Chemicals
Pigments
Compound Preparation (Banbury)
Waste 1,2,5
Fabric Coating (Calenders)
Waste 2,3
Foam Molding (Innersole)
Waste 2
Extruder
Waste 2
Cutting Room
Waste 2,3
Metal Fittings
Building Line
Waste 2,3,4
Curing Room
Molding Press Room
Waste 2,3
Quality Control
Rejects 2,3,4
Repair
First Quality
2nd & 3rd Quality
Product Shipments
Type of Waste Code
1—Paper, Cardboard
2—Rubber Compound
3—Textile Materials
4—Metals
5—Other

FIGURE I-7 SCHEMATIC DIAGRAM OF CANVAS AND WATERPROOF FOOTWEAR PROCESSES

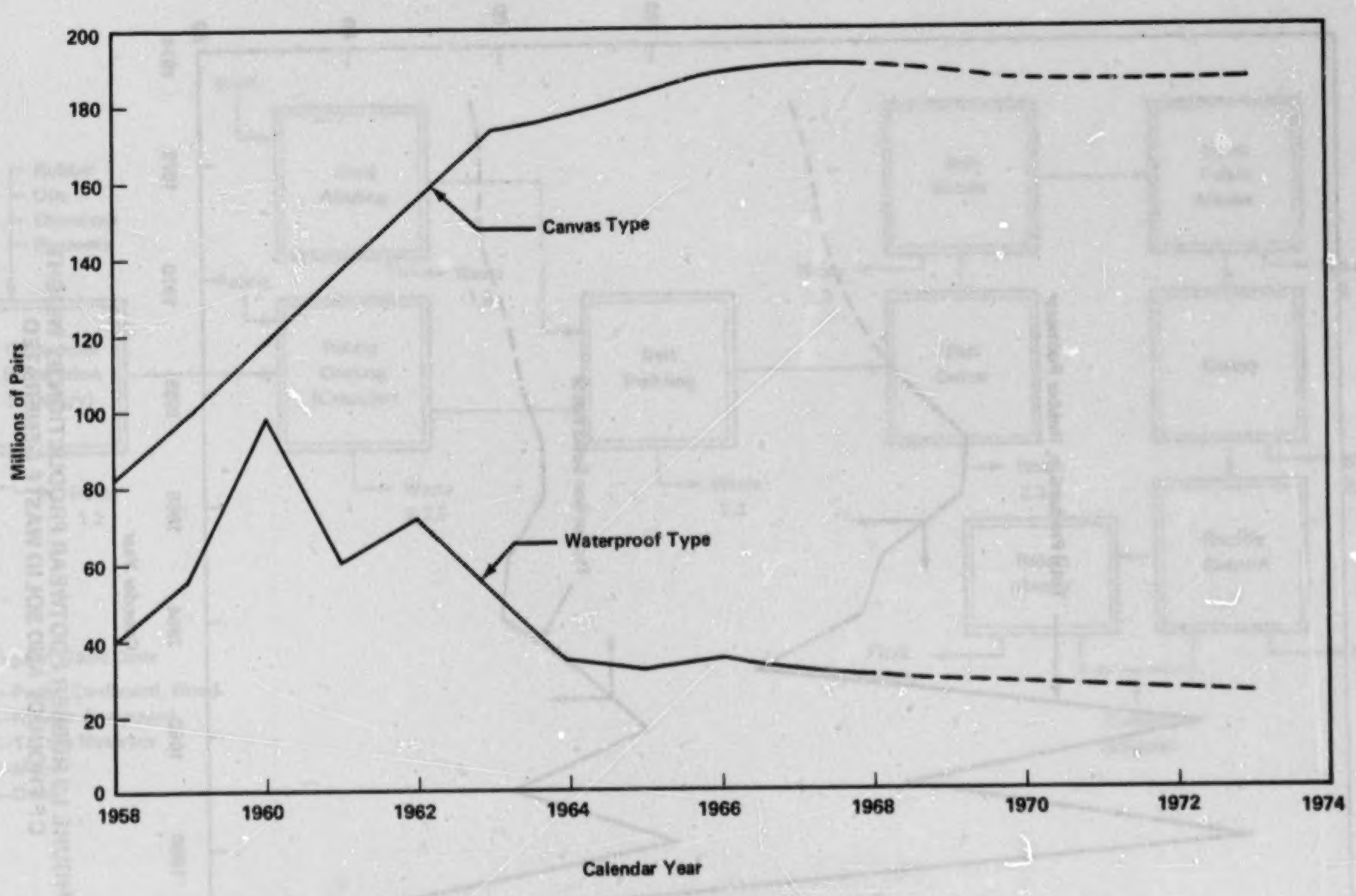


FIGURE I-8 PRODUCTION OF RUBBER FOOTWEAR BY NUMBER

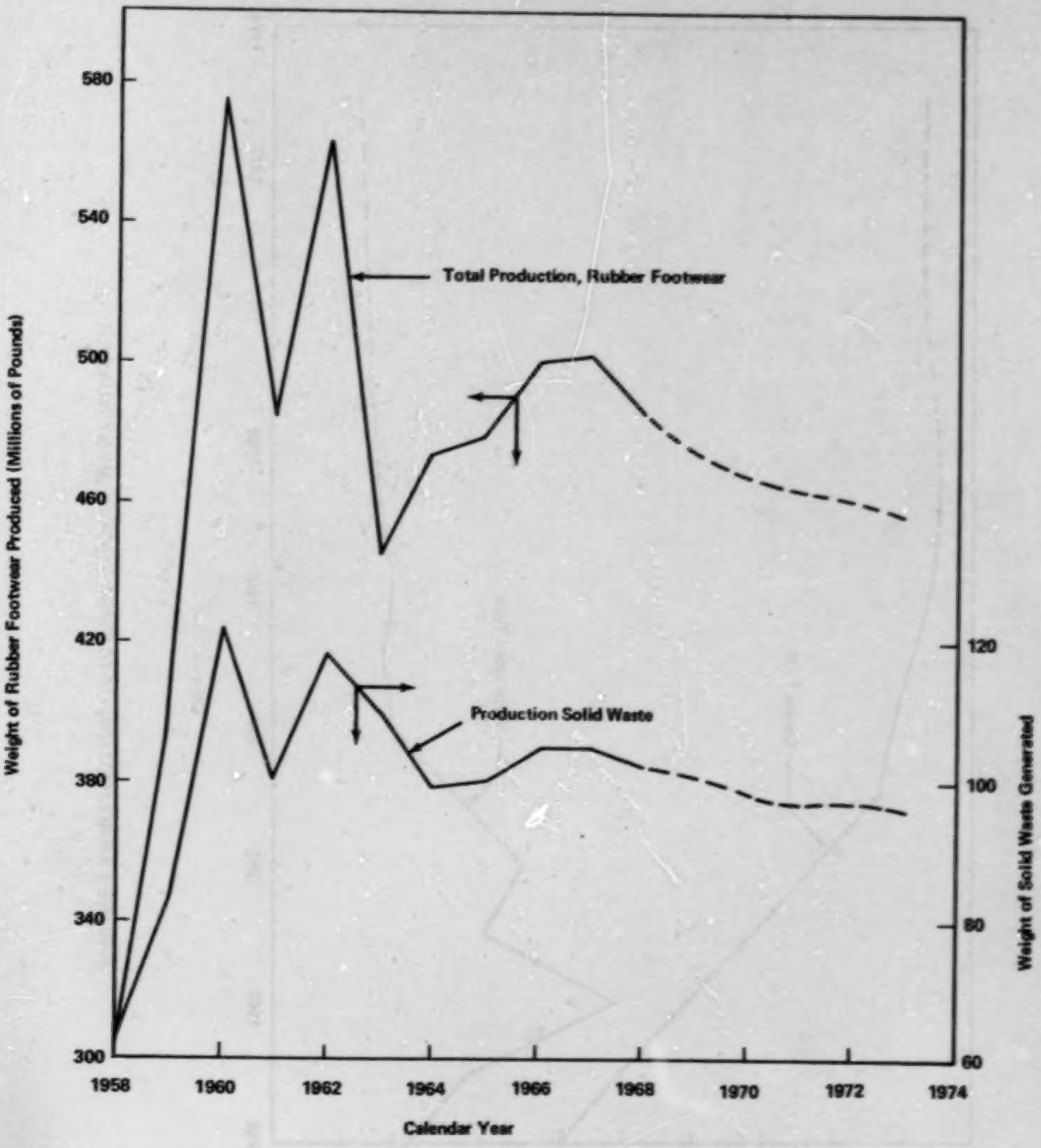


FIGURE I-9 RUBBER FOOTWEAR PRODUCTION BY WEIGHT OF PRODUCT AND SOLID WASTE GENERATED

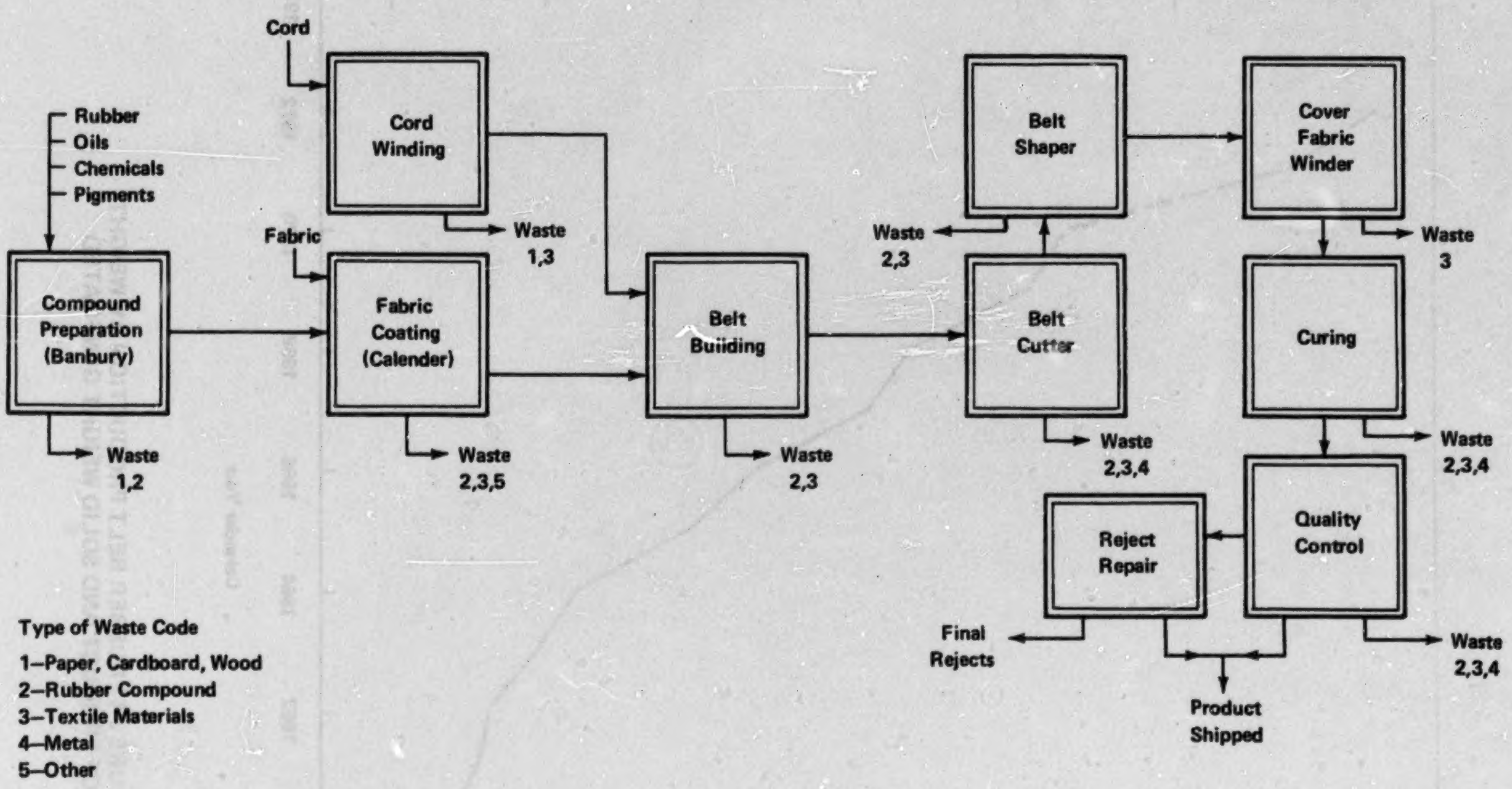

Rubber
Oils
Chemicals
Pigments
Compound Preparation (Banbury)
Waste 1,2
Cord
Cord Winding
Waste 1,3
Fabric
Fabric Coating (Calender)
Waste 2,3,5
Belt Building
Waste 2,3
Belt Cutter
Waste 2,3,4
Belt Shaper
Waste 2,3
Cover Fabric Winder
Waste 3
Curing
Waste 2,3,4
Quality Control
Waste 2,3,4
Reject Repair
Final Rejects
Product Shipped
Type of Waste Code
1—Paper, Cardboard, Wood
2—Rubber Compound
3—Textile Materials
4—Metal
5—Other

FIGURE I-10 SCHEMATIC DIAGRAM OF RUBBER BELTING PROCESSES

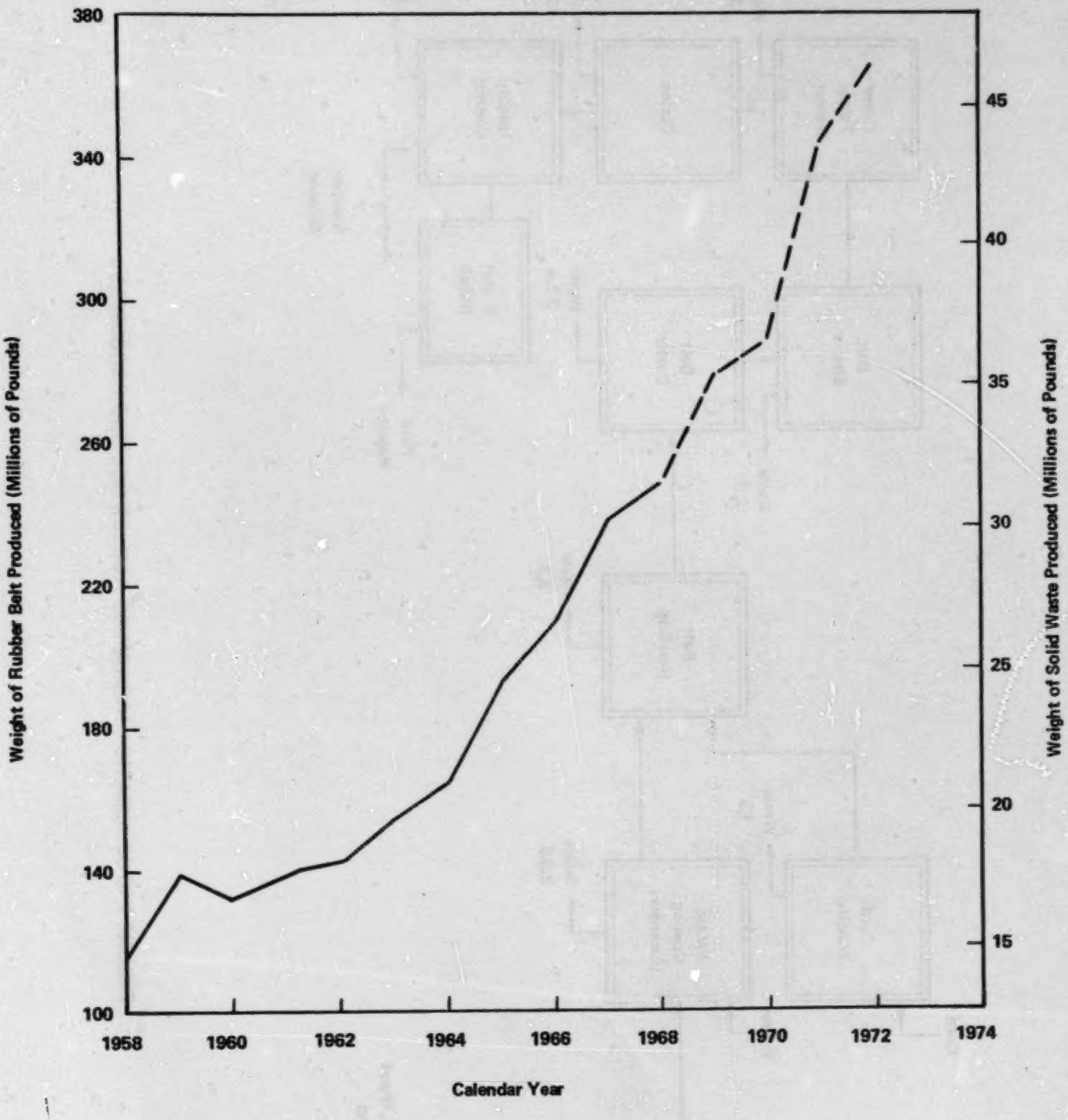


FIGURE I-11 RUBBER BELT PRODUCTION BY WEIGHT OF PRODUCT AND SOLID WEIGHT GENERATED

up of all types of household, retail service, appliance, industrial and marine hose and tubings which are made in part of rubber, with the exception of small medical tubing. The types range from very small laboratory and instrument tubings to very large and massively reinforced hydraulic mining and dredging hose. Some types are solid rubber compound, some such as firehose are nearly all fabric with a minimum of rubber, and some are composites heavily armored or reinforced with metal wire. The metal couplings are attached in the factory except for lighter hose and tubings. The one thing in common is that they are intended to convey liquids and gases and are at least semi-flexible.

This survey is estimated to have covered 65 percent of the total production of rubber hose. There are a large number of small specialty manufacturers who could not be visited but their processes would be much the same as those reported. The table below will show the coverage.

MAJOR

	Corp.	Plants
Industry	**10**	**20**
This study	**8**	**8**

MINOR

	Corp.	Plants
Industry	**115**	**more than 130**
This study	**5**	**5**

Most of the major producers make a wide variety of hose types in a single plant and they were unable to provide data by type. The average solid waste generated per million pounds of hose produced is as follows:

Type of waste	Millions of pounds per million pounds of product
Paper, cardboard and wood	33,300
Rubber compound	54,700
Textile material	18,300
Metal	10,200
Other	49,300
Total waste	165,800

The paper scrap is largely from raw material packages but contains as well, non-returnable wire reel cores and textile yarn cores. Most of the reinforcing jackets are braided from textile yarns or wire and little or no woven or knit fabric is used. Most of the hose plants are old and not well adapted to automation, a large variety of sizes and styles are made in most plants, and the hose is built to rigid specifications. These factors all tend to make in-process spoilage a serious contributor to rubber compound and textile waste. Since the textile fabric is braided in place, there is little trimming and cutting waste as there is in the other parts of the rubber product industry. There is little possibility of salvaging the steel wire or steel jacket material but the non-ferrous materials in reject fittings are either renovated and re-used as such or sold as high value merchant scrap.

Because of rigid performance specifications and quality control standards rejects are high. In the past it was customary to cut rejects into "short ends" and sell them as substandard lengths for non-specification applications. Because of misuse of these products and severe manufacturer's liability rulings, it is no longer possible to dispose of most rejects in this fashion and they must be spoiled and become solid waste. The finished product rejects that must be scrapped run 8-12 percent of total production and their weight is included in the tabulation above.

Much hose is cured in a temporary lead sheath to permit the use of internal pressure. This lead is stripped in the process and re-used over and over until it is too contaminated to work well. The contaminated lead is sold at scrap metal prices for refining and re-use. Some lead oxides and dross probably get into other waste and is reported as such.

A schematic diagram of hose manufacture is given in Figure I-12 and the history and forecast shown in Figure I-13. The industry is thriving, thanks to growth in automotive and appliance demands–especially automotive air conditioning. The growth in marine shipments of petroleum and chemicals has required large amounts of large hose for product transfer.

SPONGE AND FOAM RUBBER PRODUCTS

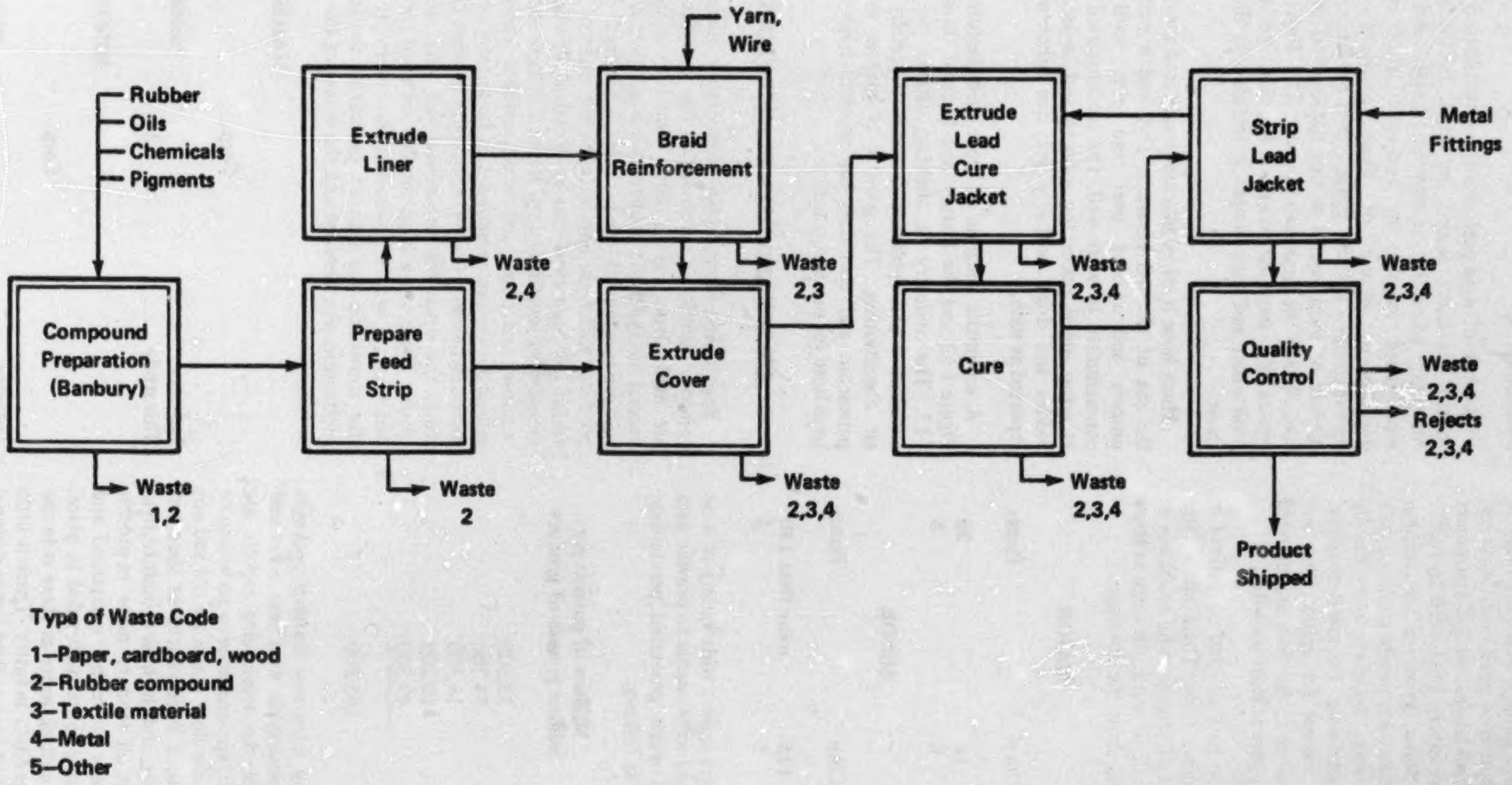
Sponge and foam rubber products are included in S.I.C. category 30693. This includes all the foam products which are made from rubber latex, which is a suspension of natural or synthetic rubber in water, such as cushioning, mattresses, pillows, and carpet underlays. The sponge products which are also included are made of solid rubber which has been expanded by chemical blowing agents and includes various insulation items, flotation items, seals for windows and doors, and carpet padding. The products are essentially rubber compounds as they rarely contain textile materials or metal inserts. Although the range of products is wide, the operating procedures are very similar for all plants. There are a large number of small specialty plants which could not be covered in this survey. It is estimated that something less than 25 percent of the total industry production was included and the extent of the interviews is as follows:

MAJOR

	Corp.	Plants
Industry		**more than 125**
This study	**2**	**3**

MINOR

	Corp.	Plants
Industry		**more than 150**
This study	**4**	**4**



Rubber
Oils
Chemicals
Pigments
Compound Preparation (Banbury)
Waste 1,2
Extrude Liner
Waste 2,4
Prepare Feed Strip
Waste 2
Yarn, Wire
Braid Reinforcement
Waste 2,3
Extrude Cover
Waste 2,3,4
Extrude Lead Cure Jacket
Waste 2,3,4
Cure
Waste 2,3,4
Strip Lead Jacket
Metal Fittings
Waste 2,3,4
Quality Control
Waste 2,3,4
Rejects 2,3,4
Product Shipped
Type of Waste Code
1—Paper, cardboard, wood
2—Rubber compound
3—Textile material
4—Metal
5—Other

FIGURE I-12 SCHEMATIC DIAGRAM OF RUBBER HOSE PROCESSES

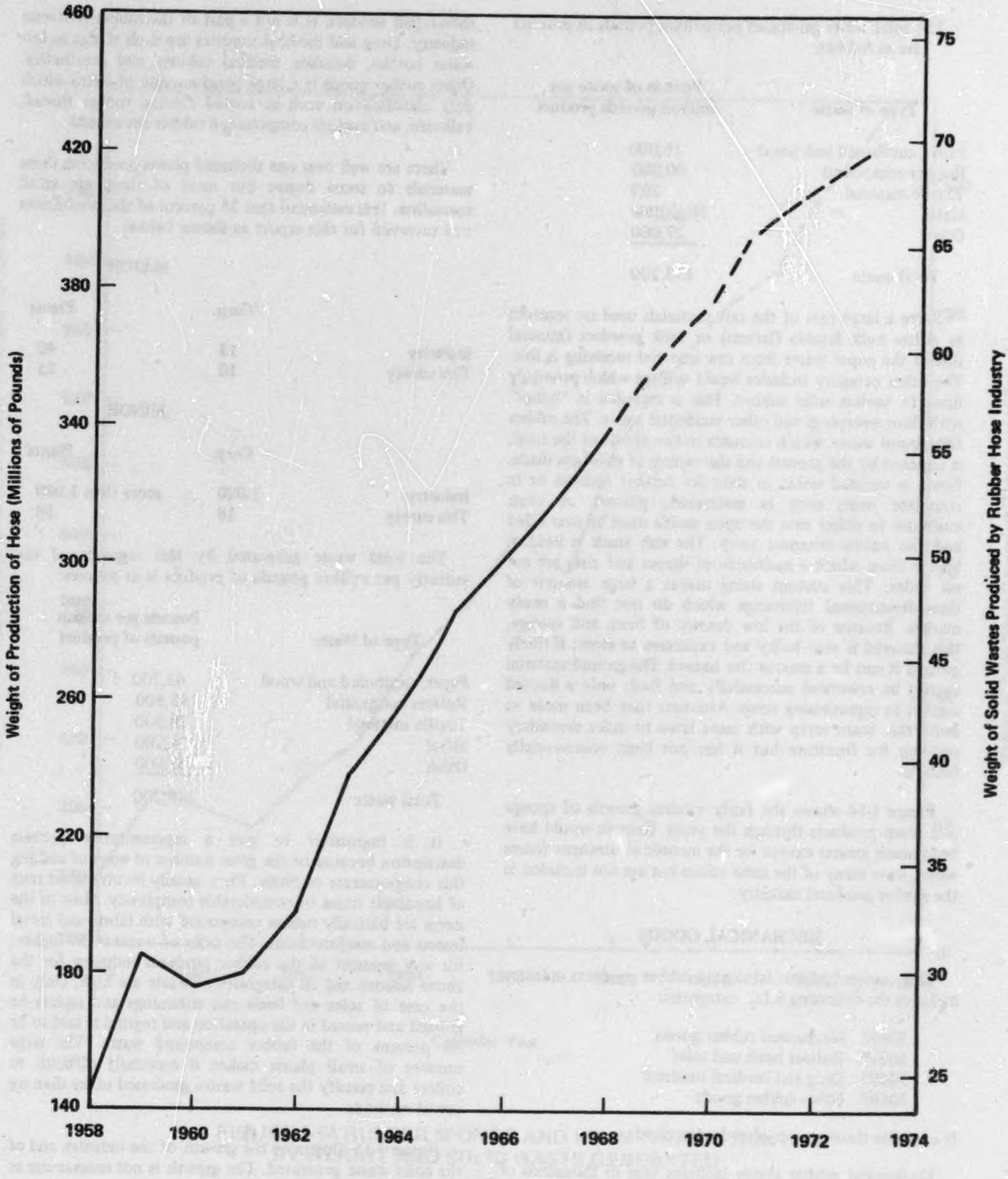


FIGURE I-13 RUBBER HOSE PRODUCTION BY WEIGHT AND SOLID WASTE GENERATED

The solid waste generated per million pounds of product are as follows:

Type of waste	Pounds of waste per million pounds product
Paper, cardboard and wood	16,000
Rubber compound	90,000
Textile material	200
Metal	Negligible
Other	27,000
Total waste	133,200

Since a large part of the raw materials used are received as either bulk liquids (latices) or bulk powders (mineral fillers) the paper waste from raw material receiving is low. The other category includes liquid spillage which promptly dries to useless solid rubber. This is included in "other" with floor sweepings and other incidental waste. The rubber compound waste, which amounts to two-thirds of the total, is imposed by the process and the variety of products made. Foam is molded either in slabs for further division or in complete units such as mattresses, pillows, or chair cushions. In either case the open molds must be over-filled and the excess trimmed away. The slab stock is used as blanks from which a multitude of shapes and sizes are cut on order. This custom sizing makes a large amount of three-dimensional trimmings which do not find a ready market. Because of the low density of foam and sponge, this material is very bulky and expensive to store; if finely ground it can be a serious fire hazard. The ground material cannot be reworked successfully and finds only a limited market as reprocessing scrap. Attempts have been made to bond this foam scrap with more latex to make secondary padding for furniture but it has not been commercially feasible.

Figure I-14 shows the fairly modest growth of sponge and foam products through the years. Growth would have been much greater except for the inroads of urethane foams which have many of the same values but are not included in the rubber products industry.

MECHANICAL GOODS

This segment of the fabricated rubber products industry includes the following S.I.C. categories:

30695	Mechanical rubber goods
30696	Rubber heels and soles
30697	Drug and medical sundries
30698	Other rubber goods

It excludes those groups already described.

Mechanical rubber goods includes tens of thousands of molded and extruded items used by industry and as components of consumer hard goods. It includes such things as seals, rolls, inflatable goods, battery cases, fuel cells for aircraft, dock bumpers, and many others. Rubber heels and soles includes these items and the slab stock from which they may be cut for use by the shoe industry and the shoe-repair services. It is not a part of the rubber footwear industry. Drug and medical sundries are such things as hot water bottles, douches, medical tubings, and prosthetics. Other rubber goods is a large conglomerate of items which defy classification such as coated fabrics, rubber thread, balloons, and custom compounded rubber for others.

There are well over one thousand plants producing these materials to some degree but most of them are small specialists. It is estimated that 35 percent of the production was surveyed for this report as shown below.

MAJOR

	Corp.	Plants
Industry	13	40
This survey	10	15

MINOR

	Corp.	Plants
Industry	1,000	more than 1,000
This survey	18	18

The solid waste generated by this segment of the industry per million pounds of product is as follows:

Type of Waste	Pounds per million pounds of product
Paper, cardboard and wood	43,700
Rubber compound	93,800
Textile material	28,500
Metal	14,200
Other	68,000
Total waste	248,200

It is impossible to give a representative process description because of the great number of ways of making this conglomerate of items. They usually involve short runs of handbuilt items of considerable complexity. Most of the items are basically rubber compound with fabric and metal inserts and reinforcement. The ratio of waste is the highest for any segment of the rubber products industry for the above reasons and all categories of waste are high. Only in the case of soles and heels can trimmings and rejects be ground and reused in the operation and regrind is said to be 50 percent of the rubber compound waste. The large number of small plants makes it especially difficult to collect and classify the solid wastes generated other than by casual methods.

Figure I-15 illustrates the growth of the industry and of the solid waste generated. The growth is not spectacular as it will have only doubled in quantity in 15 years.

WIRE AND CABLE

The wire and cable industry, which is traditionally considered part of the fabricated rubber products, is

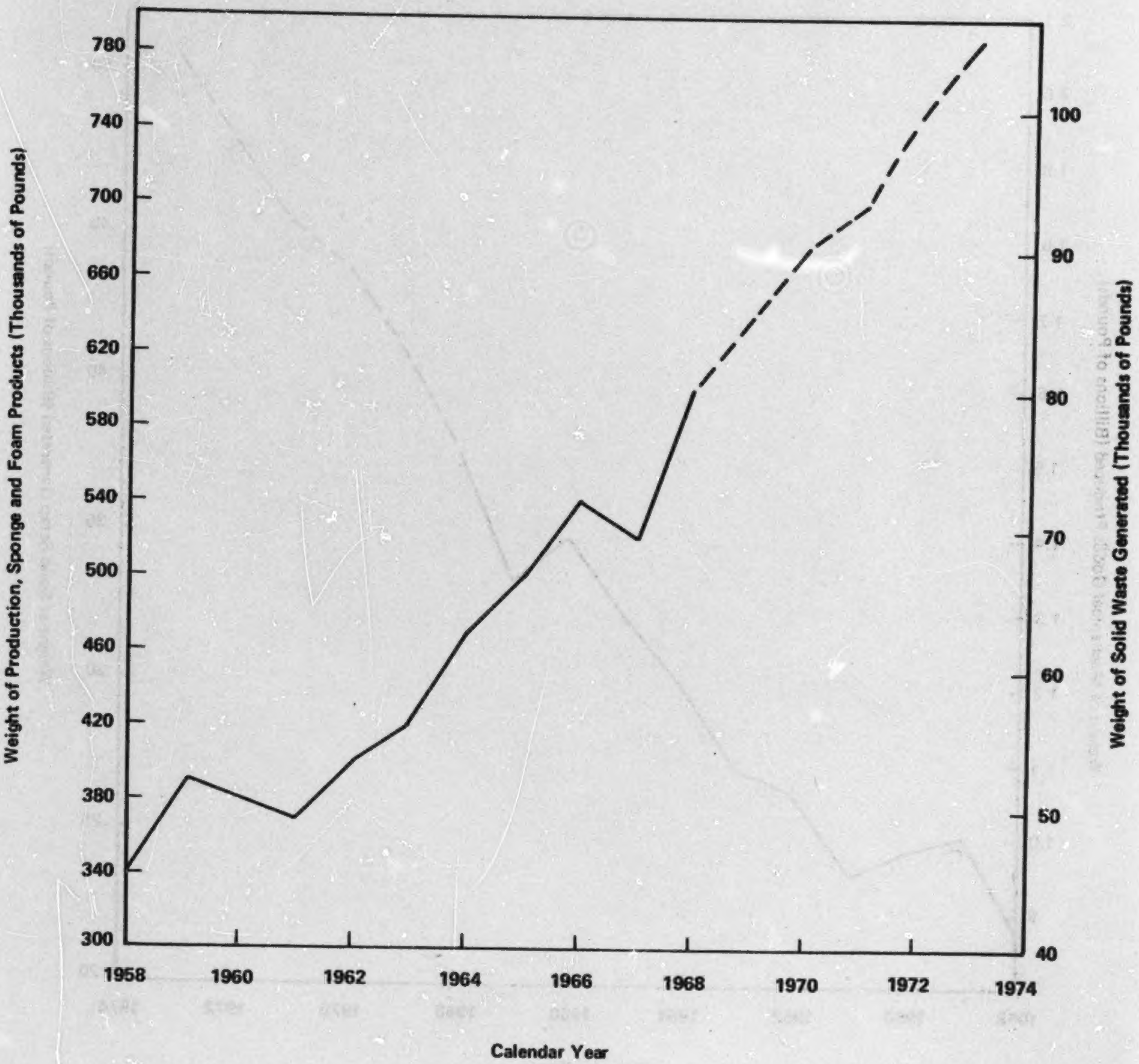


FIGURE I-14 RUBBER SPONGE AND FOAM PRODUCTION BY WEIGHT AND SOLID WASTE GENERATED

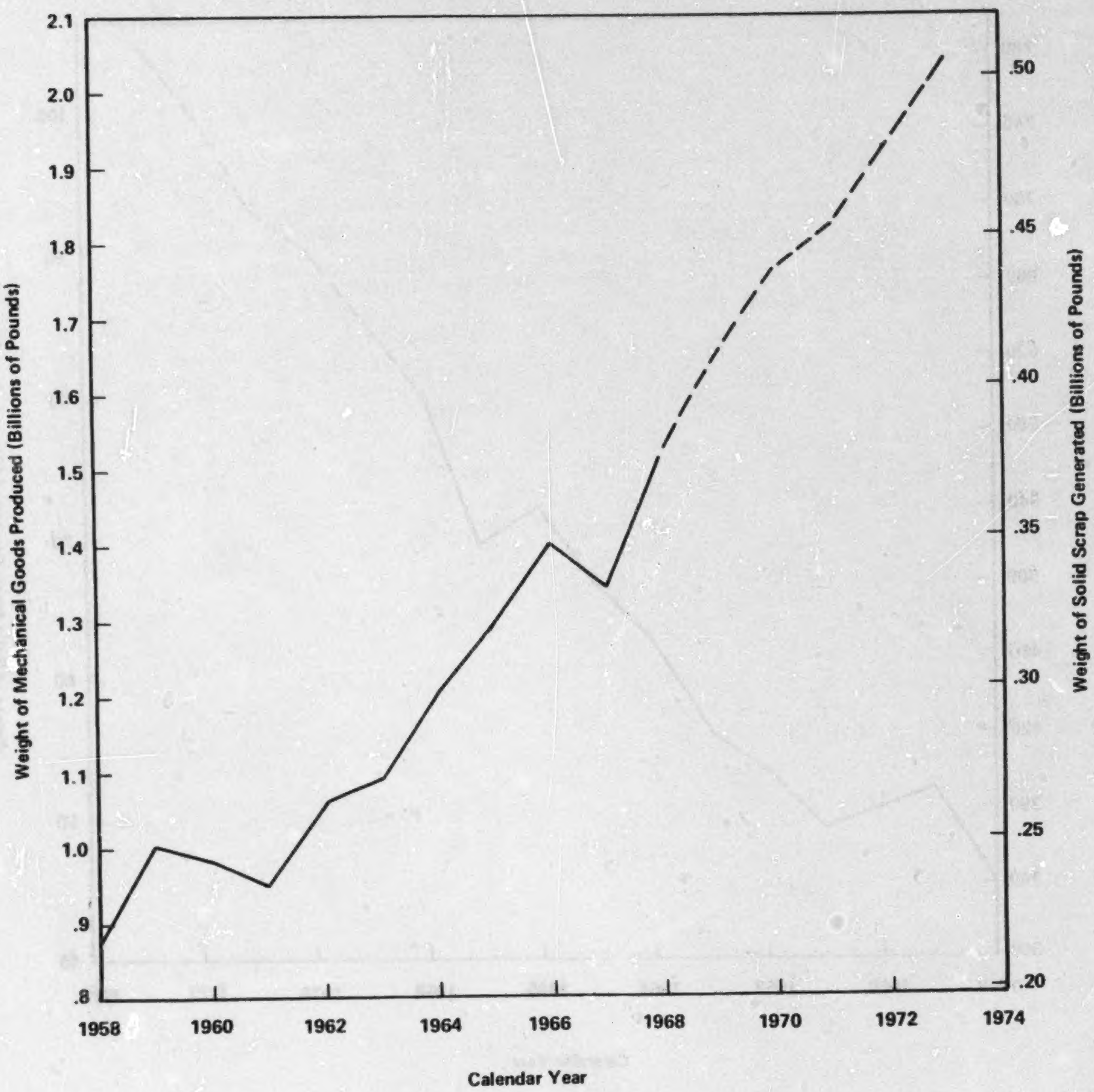


FIGURE I-15 MECHANICAL RUBBER GOODS PRODUCED BY WEIGHT AND SOLID WASTES GENERATED

described as S.I.C. 3357, Insulating of Nonferrous Wire. At one time all such power, communication, and other electrical service wires and cable were insulated and jacketed with rubber or rubber-like materials by conventional rubber processes. The rubber component was never very large in value or volume compared to the nonferrous metal used in the industry, but at one time it made up a sizable part of the rubber consumed. In the period covered by this report, the rubber usage is low, varying from three percent to one percent of total rubber consumption, because of its large replacement by plastics in many kinds of wire. The industry does pose a rather unusual disposal problem.

The industry was reluctant to give information for this survey so that not more than 10 percent of the total production is covered, but it is believed it is representative of the whole industry. The coverage was as follows:

MAJOR

	Corp.	Plants
Industry	7	10
This survey	2	2

MINOR

	Corp.	Plants
Industry	49	over 65
This survey	1	1

Some 175 million pounds of rubber compounds are mixed in these operations much as in tire plants and applied to the wire and cable in various ways, but usually by simple extrusion. The finished product is of high value and made to exacting standards on a continuous basis. Rejects develop locally in testing and these lengths are cut out. Rejects are stripped of rubber compound, which is discarded and the core rerun. If the core is damaged the rubber compound is burned off and the nonferrous core sold in the scrap metal market. The solid wastes generated in 1968 are estimated below as pounds per million pounds of compound.

Type of Waste	Pounds per million pounds of rubber compound
Paper, cardboard and wood	11,000
Rubber compound	20,000
Textile material	1,000
Other	2,800
Total waste	34,800

These numbers refer only to the rubber compound used and not to the total weight of the industry product. No metal waste is given as this is a concern of the wire industry proper. The paper waste is that from the rubber compound raw materials. The rubber compound is that which is stripped or burned off of rejects. The textile waste is the small amount stripped or burned with the rubber component.

Future consumption of rubber compound by the wire and cable industry should remain where it was in 1968, or decline slowly.

COSTS OF SOLID WASTE DISPOSAL

The unit disposal costs of the solid wastes generated by the fabricated rubber products industry are not related to the product being made or the type of waste as they are invariably mingled. Table I-4 lists in-plant and external disposal costs for twenty-one different plant sites. None are in the same metropolitan area. Specific cities were not named as it would be easy to relate to the companies surveyed. Costs marked with an asterisk are for companies falling within the 219 standard metropolitan areas.

Generally speaking, the costs in metropolitan areas are higher than in the more rural areas of the country with the exception of a few companies who own their own land fill site rather than rent one.

In-plant collection costs include all direct labor, supervision, and overhead for collecting waste from operator's receptacles and delivery to a common pickup point.

Out-plant haulage covers the contractor's price for carriage and dump fees. The contractor sometimes owned the dump, but generally paid the private or municipal fee as part of his price. This cost varies widely with local labor costs, availability of dumps, and distance to available dumps.

It was impossible to obtain any more detailed information as plant accounting systems only provide total weight of waste dumped, total in-plant costs charged to this function, and periodic billings by outside contractors.

COSTS OF COLLECTING AND DISPOSAL OF SOLID WASTES AT INDIVIDUAL PLANT SITES

Plant Site	In-Plant Collection Cost/Ton	Carting & Dumping Cost/Ton	Total Cost/Ton
1	$10	$19	$29*
2	10	6	16*
3	13	8	21
4	20	10	30*
5	10	5	15*
6	13	12	25*
7	7	8	15
8	20	20	40
9	26	13	39*
10	18	4	22
11	27	13	40*
12	15	6	21
13	17	11	28*
14	12	8	20
15	4	13	17
16	25	20	45*
17	25	12	37*
18	NA	NA	13
19	NA	NA	12
20	NA	NA	10
21	NA	NA	3

RECOMMENDATIONS

The following refers specifically to the problem of disposing of the solid wastes generated by the fabricated rubber products industry. The general problem of comprehensive consumer rubber waste disposal is discussed in Part II.

A primary interest of the rubber industry is to reduce the quantity of waste generated. When it is noted that the direct process waste (rubber compound, fabric, metal) amounts to from 3% for tires to 25% for mechanical goods based on weight of finished products, this represents a large cost in raw materials and labor already put into semifinished goods from which there is no possibility of return. In fact, it increases the cost to get rid of them. Through this study no material has been considered waste if it is sold for any value whatever and no manufacturer's value is included in the cost of disposal. The costs of all waste produced and the costs of its disposal are a charge against the product which is successfully produced and marketed. There is no better incentive for minimizing waste than profit pressure.

Management is always aware of the importance of waste disposal as a national problem, but after their best efforts to reduce the volume of their own wastage they feel they have neither time, talent, nor resources to devote to the problem. They do not consider present solid waste disposal means as acceptable, so they simply turn over their solid wastes to a contractor at a price.

The greatest need is for an economical incineration system which will perform within firm long-range and reasonable anti-pollution standards. Only a limited number of rubber products facilities would be large enough to maintain their own incinerator, but in some locations groups of these and related industries could maintain one. For isolated manufacturers, cooperation with municipal operations will be in order. The two important requirements are:

1. Early establishment of practical firm long-term standards for performance of incinerators in respect to pollution control.
2. Support and encouragement of research and design development on proper incinerators especially for operation on solid rubber wastes or a large proportion of rubber. If such incinerators could be further developed to produce process steam, they would be even more attractive as rubber fabricators are large users of low pressure steam and this might offer some return on costs.

APPENDIX A: STUDY METHODS

The first step in conducting this survey was to organize a plan and make a selection of available sources of information with the assistance and advice of experienced research, development and sales personnel of UNIROYAL, INC. and others. Preliminary discussions were conducted with production people of a few UNIROYAL fabricating plants.

The questionnaire included in this appendix was then made up in draft guided by the stated scope of the contract and the realistic situation found in the few operations investigated on a preliminary basis. This draft was then revised after consultation with the project officer and other personnel of the Bureau of Solid Waste Management. The final form included here was then submitted for official approval for use.

While awaiting this approval, all of the available economic information on the entire fabricated rubber products industry was collected and the pertinent details arranged for this report. This includes the sections on rubber consumption, product made, and value of product. This includes past history, the situation in 1968, and a preliminary estimate of the near future. At the same time trade lists of the industry were used to plan a proper cross-section of the industry by size, location, and kind of facility. This plan was made more exhaustive than it would be possible to cover because it was anticipated that some interviews would be refused for one reason or another.

When the questionnaire had been officially approved for use, telephone calls were made to fabricating companies in such a way as to concentrate travel plans with the greatest economy. The initial telephone call in each case was made to the chief officer in charge of production; usually the vice-president for production or his equivalent in smaller companies. There were some refusals for various reasons and in some cases there was referral to some other person who was delegated to handle the matter. In all, in cases where an interview was scheduled, it was done with the knowledge and approval of senior management.

When an interview was scheduled, a copy of the questionnaire was sent to the person to be interviewed for his review and so he could assemble the information necessary.

In no case was the completed questionnaire accepted by mail or by telephone questions. The data for every production facility included was collected by personal interview either at that location or at a central location where data on several facilities was available. In most cases company records or abstracts of these were freely made available to the interviewer and the more generalized information supplied. It was found in practice that the questionnaire was too elaborate for all situations, as some individual questions could not be answered by all individual plants. Also, because of the variations in records from plant to plant, it required some ingenuity to calculate them to a common basis. It was interesting that some forms of information were considered too confidential to disclose at some facilities, but were supplied freely at other facilities.

When most of the planned interviewing was completed, the plan was reviewed for completeness and some additional interviews were arranged to make the survey as balanced as possible by size, kind, and geographical location of the plants surveyed.

When interviewing was well along, collating of the information was started, and when interviewing was finished, all the information was assembled as in the body of this report and cross-checked with the industry economic summary previously made. There was some need to make follow up telephone calls to the people interviewed to clear up questions that only arose after assembly of the information.

It had been hoped to transfer the data gathered on punch cards or some other data processing form so it could be given to the Bureau of Solid Waste Management without identification of the facility involved so that they could use it for further studies without any breach of confidence. Because of the variation in record keeping and the lack of consensus as to what could be disclosed, it was found impossible to design any useful data processing system for further studies.

APPENDIX B: GLOSSARY

Aircraft tires
Specially engineered pneumatic tires for aircraft designed for massive impact loading and minimum total weight.

Air-effect vehicles
Vehicles designed to travel over land or water on a cushion of air rather than on rubber tire wheels.

Automotive
Properly any self-propelled vehicle but usually restricted to passenger cars, trucks, buses, and towed trailers.

Banbury
A high powered mixing machine of special design commonly used for blending and mixing rubber compounds.

Bead
The inelastic flanges of a pneumatic tire which firmly seat on the rim flange and securely retain the tire on the wheel when the tire is inflated.

Bead Wire
A high strength carbon steel wire which is precisely coiled to form the core of the bead.

Carcass
Applied to the rubber and fabric body of the tire exclusive of the all-rubber tread and sidewalls.

Casing
Restricted to an unmounted pneumatic tire, in contrast to tire which is the general term for the periphery of any wheel.

Chemicals
In rubber compounding the principal chemicals are various sorts of cure accelerators, antioxidants, antiozonants, and other organic chemicals used to protect rubber against degradation by service and environmental agents.

Cord
Tire cord is a specially engineered rope-like structure of high strength made of nylon, rayon, polyester, glass or other fibers.

Consumer and industrial products
Consumer products are those which are distributed directly to the ultimate consumer such as footwear, medical supplies, replacement tires, or replacement parts for appliances. Industrial products are those sold to industry as operating supplies or as parts for new composites such as belts, hose, seals, and original equipment tires.

Cores

Are the wood, metal, paper or other sorts of cores on which cord, fabrics, wire and other raw materials are supplied to the fabricated rubber products industry. They are usually returnable and reusable, but if damaged in the rubber plant they are disposed of with the other solid wastes at that location.

Counter Stock

The stiff board-like material made of rubber, textile, and paper fiber and used as protection and stiffening of shoe toes, heels, and uppers. Since it is concealed, much plant scrap is used in its production.

Curing Bag

A tire-like structure of rubber compound and some fabric which is inserted inside an uncured tire when it is placed in the curing mold to provide pressure and internal heat. The curing bag is expendable after several hundred uses.

Cured Stock

Any rubber compound, with or without fabric, which has been subjected to heat and is no longer thermoplastic.

Damaged Stock

In-process material which has been made useless for its intended purpose by accidental semi-curing, by color change, by errors in preparation, by water or steam damage, or other processing accidents. Usually such materials can be blended off in small amounts with fresh material, but some cannot be utilized or sold to others for some value and becomes solid waste.

Dunnage

Wood, cardboard, or paper which is used to secure raw materials or equipment in rail cars or trucks. There is a strong trend to returnable dunnage, but there is still much that must be disposed of at the receiving point as solid waste.

Elastomer

An elastomer is a substance which is capable of being altered by curing to a condition in which if stretched to a limited degree at room temperature it will return to substantially its original dimensions in a short time when released. All of the so-called rubbers and a few other organic substances are elastomers.

Extrusion

A process by which a thermoplastic material is forced through a forming die to produce continuous lengths of pipe, tubes, and a variety of profiles. Extrusion is applied to uncured rubber, to many plastics, to metals, and many other thermoplastic materials.

Fabric

Fabric for the purposes of this report means any sheet goods made of natural or man-made textile fibers by weaving, knitting, braiding, or non-woven processes. It includes fabrics laid in place of tire cord.

Fabricator

For the purposes of this report a fabricator is any installation which receives raw materials or semi-processed goods from others and converts them into complex finished products for consumer or industrial sale.

Farm Tires

Includes all off-the-road tires which are used in agriculture ranging from those on garden tractors to those on massive specialized ploughing and harvesting rigs. The heavily lugged tires used on standard size farm tractors account for the largest share of the total weight. Farm tires seldom wear out in the usual sense, but are destroyed by irreparable damage from stones or roots or environmental degradation.

Fittings

Those ferrous, non-ferrous, or plastic parts which are purchased from others and made an integral part of fabricated rubber products. Examples would be brass hose couplings, inner tube valves, metal or plastic zippers for footwear, shoe eyelets, and buckles for arctics.

Flaps

A tape used to protect casings and inner tubes from abrasion of damaged metal wheels.

Floor Sweepings

In this report floor sweepings are the miscellaneous collection swept up by factory and office janitors and consists of spilled raw materials, paper scrap, staples, nails, and earth materials from outside. There is no way of characterizing it except to include it in "other solid waste."

Foam

The cellular rubber product made from liquid rubber latex by whipping air into it, as distinguished from sponge (see below).

Inner Soles

The structural padding in the bottom of all types of footwear. It may be a cushion of sponge rubber or a rigid concealed sheet stock.

Inner Tube

The inflatable torus ring which is the air container in heavy duty tires and in some medium duty tires. They are nearly pure rubber compounds and almost always made of butyl rubber because of its resistance to air diffusion.

Inserts

A wide variety of metal or plastic shapes which are bonded to or contained within the finished rubber article. The threaded closure in the neck of a hot-water bottle is a good example.

Latex

A suspension of very small solid rubber particles in a water solution. Natural rubber exudes from the tree in this form and most synthetic rubbers are produced in this form or easily converted to a latex. Latex is used in the manufacture of foam, dipped goods, carpet backings, and other coatings and adhesives. They are distinguished from cements which are solvent solutions.

Mineral Fillers

Fine ground mineral powders which are added to rubber compounds to improve properties, to increase density or decrease cost. Common ones are clays, whiting, magnesia, zinc oxide, asbestos, and lead compounds.

Molding

The process of forming rubber products with heat and pressure in precision formed molds. Various forms of molding are compression, transfer, injection, slush, rotational, and open mold. Compression molding is the traditional process for rubber products, but injection molding is becoming more common because of greater efficiency. Plastics are molded by very similar processes.

Molding Waste

The overflow from the molding process including that from the air release channels built into the mold. Mold waste is always cured so it cannot be conveniently re-mixed.

Natural Rubber

Rubber originating from natural sources, almost entirely the cultivated rubber tree of Southeast Asia, Indonesia, Ceylon, West Africa, and a few minor tropical sources. It is marketed as either solid rubber or the concentrated latex.

Pallets

Wood, paper, or plastic supports for piles of bags, bales, or rolls of raw material to facilitate semi-automatic handling. They may be either disposable or returnable. One-trip pallets or damaged returnable pallets become solid waste at the point of delivery.

Pigments

Are strictly speaking organic or inorganic powders used to color rubber products. They include many mineral products such as titanium oxide or zinc oxide which make white products. The terms pigment and mineral filler are often used interchangeably.

Pneumatic Tires
Tires containing an enclosed air space and having an elastic and resilient body, the combination giving a smooth jolt-free motion to vehicle on rough road-beds.

Polymer
A high molecular weight material made up of similar repeated units of simple structure. All rubbers are polymers but the term includes most plastics and many biological materials.

Product Package
Most consumer items and many industrial products are marketed in some type of package for protection, identification, or customer appeal. The package may be a cardboard box, a paper jacket, paper wrapping, or a multitude of other types. Sometimes a group of boxed items are shipped together in an outer case. This material becomes solid waste at the point of ultimate consumption and its weight is omitted from any numbers in this report as it is obviously not a waste generated by the fabrication of rubber products.

Quality Control
This incorporates all physical, chemical, or service testing of raw materials, in-process material, and finished product to insure that products meet the desired or required test specification. It would include all research and development products where this work is associated with a producing facility. Much of the raw material and in-process material could be returned to process, but much would be subjected to curing for test purposes and this, together with spoiled finished product, would be disposed of as solid waste.

Reclaimed Rubber
The product of physical or chemical processes which convert scrap rubber products from any source into material which has a limited use as a raw material for the fabricated rubber products industry and certain other industries. It will be discussed in detail in Part II of this report; in Part I it is considered as only another raw material.

Rejects
Finished product which is judged by test to not conform to established quality standards. In some cases a reject can be repaired (belting and hose), or sold commercially as second or third quality (footwear), or reprocessed (heels and soles). In many cases repair or sale as off-quality cannot be tolerated and the item must be made unserviceable and disposed of as solid waste (tires, inner tubes, hose).

Retreading
The process by which sound tire carcasses which have had the tread worn beyond safe levels by normal operation are rejuvenated by molding on a new tread equivalent in safety performance to the original.

Rubber
An unfortunately vague word having many different common and technical meanings. Originally meaning the crude natural product. It now covers all the synthetic elastomers, compounds of them, and fabricated products. It also refers to the "rubbery" properties of things that may not be elastomers at all. Then specifically it may refer to such things as waterproof footwear, prophylactics, and many other items.

Rubber Compound
Intimate mixtures of elastomers, oils, mineral fillers, pigments, chemicals, sulfur, and other modifying materials. It usually refers to uncured material.

Rubber Mill
An open mixer for making rubber compounds consisting of two powered rolls operating in opposite or the same directions, at various rotational ratios, and either smooth or grooved in various ways.

Semi-pneumatic
A tire of heavy construction having an air space within it usually at atmospheric pressure. They provide much less cushioning than pneumatic tires and are used on light weight equipment or industrial units.

Separators
Sheets of plastic, paper, or treated fabric which are used to temporarily separate prepared pieces of tacky uncured rubber prior to assembly. The trend is to plastic film which can be recovered after use and reprocessed in the fabricating plant as many as six or eight times. Treated paper and fabric can be used over several times, unless it has been cut, and then must be discarded as solid waste.

Solid Tires
A solid mass of rubber built up on the rim of a metal wheel with no substantial air space. Usually limited now to small heavily loaded wheels and rollers such as aircraft tail wheels, industrial tractors, and conveyor rolls and casters.

Sponge
Cellular rubber products made from softened solid rubber products containing chemical agents which decompose to gases during the curing process.

Tire Accessories
Products associated with tires and wheels exclusive of casings and inner tubes. Includes retreading compound, flaps, repair patches, and cement, and a variety of small specialty wheels and parts.

Tread
That part of the tire casing which comes in contact with the road. It contains no fabric and is specially designed for abrasion resistance and maximum skid resistance under all driving conditions. This part of a sound tire can be effectively replaced by retreading.

Trimmings
Almost all fabricated rubber products are assembled from sheet or strip rubber compound, fabric or metal by hand or semi-automatic operations. This requires much hand or machine trimming of excess material to make the final shapes required. Much of these trimmings may be reprocessed but the remainder is discarded as solid waste.

Wire and Cable
This includes all electrical conductive power, communication, and electronic wires and cables. At one time all the insulation and jacketing of the non-ferrous conductor was based on elastomers but now much of the elastomer has been replaced by plastics such as polyolefins and polyvinyl chloride which do not require a curing stage as elastomers do. The remaining use of elastomers is in applications where its abrasion resistance, moisture resistance, and electrical properties are superior at lower cost. The performance specifications in most of this industry are very rigid.

Rubber Reuse and Solid Waste Management

Part II

WASTE RUBBER AND ITS REUSE: 1968

Part II of this publication (SW-22c) was written
for the Federal solid waste management program by
WALTER J. MARKIEWICZ and MICHAEL J. GRANSKY
Uniroyal Chemical, a division of Uniroyal, Inc.
under Contract No. PH 86-68-208

U.S. ENVIRONMENTAL PROTECTION AGENCY
1971

Preface

This report on solid wastes of the Rubber Industry was prepared by Uniroyal Chemical, a division of Uniroyal, Inc. pursuant to Contract No. PH 86-68-208, with the Federal solid waste management program (now part of the U.S. Environmental Protection Agency). The statements, findings, conclusions, recommendations, and other data in this report are not necessarily those of the Agency, nor does mention of commercial products imply endorsement by the U.S. Government.

Valuable support was provided by the Commercial Development and the Research and Development Staffs of Uniroyal Chemical and by the Economic Analyses and Long Range Planning Staff of Uniroyal, Inc.

Acknowledgments

A study such as the present one which encompasses the whole of a very large industry could not have been successful without the generous cooperation of many individuals in that industry. We wish to express our thanks for the assistance of the personnel of the following companies:

Amerace Corp.
Butler, New Jersey

A. Baker Manufacturing Co., Inc.
South Bend, Indiana

Boston Woven Hose & Rubber Div.,
American Biltrite Rubber Co., Inc.
Cambridge, Massachusetts

B.F. Goodrich Co.
Akron, Ohio

Goodyear Tire & Rubber Co.
Akron, Ohio

A. Lakin & Son
Chicago, Illinois

Laurie Rubber Reclaiming Co.
New Brunswick, New Jersey

Midwest Rubber Reclaiming Co.
East St. Louis, Illinois

A. Schulman, Inc.
Chicago, Illinois

Swan Rubber Co.
Bucyrus, Ohio

Centrex Corp.
Findlay, Ohio

Firestone Tire & Rubber Co.
Akron, Ohio

Gates Rubber Co.
Denver, Colorado

Uniroyal, Inc.
New York, New York

U.S. Rubber Reclaiming Co., Inc.
Vicksburg, Mississippi

Associations

The Asphalt Institute
College Park, Maryland

The National Tire Dealers and Retreaders Association, Inc.
Washington, D.C.

The Rubber Reclaimers Association, Inc.
New York, New York

PART II: CONTENTS

Page

SUMMARY 35

INTRODUCTION 37

SECTION I–WASTE RUBBER: 1968
- Distribution of Scrap Rubber Products 40
- Collection of Consumer Rubber Product Waste 43
- Present Reuse of Waste Rubber 43

SECTION II–THE RECLAIMED RUBBER INDUSTRY
- History of the Reclaimed Rubber Industry 48
- The Reclaimed Rubber Industry 49
- Waste Rubber Input 51
- Industry Solid Waste 52
- The Reclaiming Processes 56
- Trends in the Reclaim Industry 59
- Processing Advantages and Cost Savings 61
- Reclaim Exports/Imports 61

SECTION III–THE RETREAD INDUSTRY
- History 65
- The Retread Industry 65
- Processes 66
- Trends in the Industry 67

SECTION IV–THE TIRE SPLITTING INDUSTRY
- History of the Tire Splitting Industry 72
- Tire Splitting Industry 72
- Solid Waste and By-Products from Industry 72

SECTION V–MITIGATION
- Solid Waste Rubber Management Program 76
- Collection 76
- Shipping and Storage 76
- Potential Reuse with Reprocessing 77

SECTION VI–CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER ACTION

APPENDIX I – GLOSSARY 82

APPENDIX II – BIBLIOGRAPHY 83

INDEX

TABLES

Page
II-1 Distribution of Consumer Rubber Products Waste by States 42
II-2 Waste Rubber Used and Available: 1968 43
II-3 Tire and Other Waste Reuse 44
II-4 Reclaim Plant Locations 49
II-5 Reclaim Production as a Percent of Capacity 50
II-6 1968 Rubber Waste Usage by Reclaimers 51
II-7 Reclaim Industry Solid Waste: 1968 52
II-8 Reclaim Consumption by Product 60
II-9 Production of Retreaded Tires 65
II-10 Weight of Worn Tires Used in Retread Industry 66
II-11 Buffings Produced Annually 66
II-12 Total Waste from Retreading Industry: 1968 66
II-13 Tire Splitting Material Balance 72
II-14 Tire Splitting Industry Waste 73
II-15 Estimated Cost of Portable Rubber Waste Chopper 76

FIGURES

II-1 Geographic Percent Distribution of Waste Rubber 41
II-2 Discarded Tire Destination 45
II-3 Reclaim Plant Locations 50
II-4 Digester or Wet Reclaim Process 53
II-5 Pan or Dry Reclaim Process 54
II-6 Rubber Crumb Process 55
II-7 Reclaiming Process Chart 57
II-8 Reclaim Consumption as a Percent of Total New Rubber 59
II-9 Reclaim Exports/Imports 62
II-10 Domestic Passenger Tire Shipments and Retreads 68
II-11 Domestic Truck Tire Shipments and Retreads 69

Summary

This report outlines the waste rubber product disposal problem, the present areas of waste reuse with future trends, and potential future areas of collection and reuse. The base year was taken as 1968.

Section I presents (a) the geographic distribution of two categories of rubber waste, one category being more easily collectable than the other; (b) the collection methods presently used for waste now reused and (c) the wastes consumed by the three major users.

Section II details one of the waste users, the Reclaim Rubber Industry, its history, the wastes used and created, the processes used, and the industry trend.

Section III details the Retread Industry, the largest single user of rubber waste, its history, wastes used and created, the process and industry trend.

Section IV outlines the smallest of the waste reusers, the Tire Splitting Industry.

Section V is an analysis of the various methods of waste collection and reuse which might be used for mitigating the problems caused by rubber product waste.

Section VI presents some specific conclusions and recommendations for further action.

Section I
Of the 10.7 billion pounds of rubber products produced in 1968, after wear allowed for in vehicle tires, approximately 10.3 billion pounds will ultimately become a waste disposal problem.

Approximately 6 billion pounds will be various types of tires for automotive, truck and farm vehicles. It is mainly this type which is presently used in any significant quantities by the three major waste reusers, amounting to 1.95 billion pounds.

Approximately 11% of this collected waste* or 213 million pounds is subsequently rejected for various reasons by these industries as waste for disposal.

The overall net waste for disposal is then estimated at 8.6 billion pounds consisting of 4.3 billion pounds of tires and 4.3 billion pounds of other rubber product waste.

Twenty million pounds of new waste are created during the reuse of the remaining 1.7 billion pounds of rubber waste.

Section II

Over the past 10 years, the Reclaim Industry produced between 550 to 650 million pounds per year of useable product primarily from rubber waste and rubber industry scrap. The Reclaim Industry waste consists of 62 million pounds of unused waste and 13 million pounds of newly created waste.

During this 10 year period, reclaimed rubber as a percent of new rubber polymer has decreased from 18% to 10% indicating a loss of market or usefulness to the rubber industry. It is anticipated that the pound volume will continue to decrease in the near future.

Section III

The largest users of rubber waste are the tire retreaders who accumulated 1.6 billion pounds of road worn tires. Approximately 1.56 billion pounds were recycled back to consumers with the addition of approximately 530 million pounds of new tire tread. The remaining 0.04 billion pounds of worn tires were rejected as unsuitable for retreading. The tread rubber added to the 1.56 billion pounds of tires is included in the 10.7 billion pounds of new rubber products made in 1968. Newly created waste was 4 million pounds. There has been a steady though small increase in the numbers of tires being retreaded every year particularly the heavy service truck type tires and this increase is expected to continue. Without this recycle of worn tires back into service, it is logical to assume that more new tire production would be necessary to satisfy the market thereby increasing the future tire waste from 6 billion pounds per year to well over 7 billion pounds.

Section IV

The tire splitting industry uses rubber waste, mainly tires, to produce rubber washers, gaskets, shims, automotive tail pipe hangers, and the familiar door mats. Of the 57 million pounds consumed by the industry, 14 million pounds were converted into finished products, 36 million pounds were sold to reclaimers as selvage, and 7 million pounds were returned to waste. There was 3.6 million pounds of new waste created by this industry. Without past history on volume of waste consumed, it is difficult to establish industry trend, however, it is an industry expectation that volume will continue to increase.

Section V

It is suggested that the rubber waste program be divided into two categories, tire waste and others. A collection system already exists for waste tires to serve the three major users, collecting approximately 30% of those available. It may be possible to expand this system as a nucleus for collection of the remaining 70%. The "other" category will be extremely difficult to collect and sort into useable waste. Alternate collection systems and storage sites are considered. Methods for facilitating disposal of rubber waste through incineration or land-fill were considered including stationary and portable shredders; the use of shredded waste in roads, crash barriers, as a mulch or road banks was also considered as well as the longer range potential outlets as pyrolysis to either chemicals or fuel gasses.

Section VI

Seven specific recommendations are presented for future study. The logistics of waste collection oriented primarily to tire accumulation should be investigated. A study based on the reverse logistics of new tire distribution is suggested. Facilities for shredding and densifying waste followed by incineration or conversion to other useful products are discussed. The use of waste rubber in asphalt roads will require specific studies and test roads. It is also recommended that the Bureau of Solid Waste Management maintain surveillance over legislation, industry standards, and technological changes to ensure that the solid waste problem is not inadvertently aggravated.

Introduction

This report outlines the entire Waste Management problem concerned with discarded consumer rubber products based on products manufactured in 1968 and waste products also reused in 1968.

While the rubber products industry has been growing at a steady pace as described in Part I of this report, the waste reuse or management in pounds in recent years has remained virtually constant. The overall effect is a lower percent of waste reused. The three largest (virtually 100%) users of waste rubber products show the following usage changes between 1963 and 1968 respectively. Reclaimers produced 0.629 billion pounds vs. 0.576 billion pounds. Retreaders reused 1.43 vs. 1.56. No comparative data are available for splitters which is small usage by comparison. The overall total was 2.06 billion pounds reused in 1963 vs. 2.13 billion pounds in 1968.

Although minor favorable cost differentials may exist between reused rubber products such as reclaim and retreaded tires, other disadvantages – real (potential by lower quality) or imaginary (second class reused stigmatism) – have precluded any significant growth in usage.

While waste rubber products are not unique with respect to other types of waste, they have inherent in them many of the difficult disposal characteristics of the others. They come in combination with other materials as fibers and metals; are made in various sizes and shapes; are scattered over the length and breadth of the land; are not easily degradable in land fill type operations where the large items such as automotive tires have the added disadvantage of resisting compaction; and although readily combustible they contribute substantially to air pollution problems when burned in ordinary, low quality incinerators. To put this survey into perspective, Section I of this report details the geographic location of the waste, subdividing the waste into two categories. The first is all tires which constitutes approximately 59% of the total waste and which is more readily collected and reused. The second category is the broad "Others" which covers a multitude of rubber products, difficult to collect, sort, and reuse in any foreseeable outlet. Section I also outlines the three major industries engaged in the reuse of waste rubber products.

Section II covers one of the waste converters, the Reclaim industry, its history, the wastes used and created, an outline of processes and equipment used, and the industry trends. Sections III and IV similarly outline the other two major uses of rubber waste, the Retreaders and Tire Splitters respectively.

Section V outlines some broad solutions to achieve more effective waste management with specific conclusions and recommendations listed in Section VI.

A Glossary and a Bibliography, subdivided in various topic classifications, are included in the two Appendices.

BLANK PAGE

Section I
Waste Rubber: 1968

Preceding page blank

DISTRIBUTION OF SCRAP RUBBER PRODUCTS

During 1968, 10.7 billion pounds of rubber products were produced in the United States. On the assumption that unless reused for another purpose after wearing out, the rubber product will be discarded in the same locale as purchased, the geographic waste distribution can then be determined. Based on information on product sales by country and metropolitan areas, TABLE II-1 details the distribution by states. The distribution is further subdivided into two categories, Tire and Others. The assumption is that the first category is more easily collected and lends itself more readily to reuse while constituting 59% of the total 10.7 billion pounds of discarded rubber products. The basis for these assumptions will be further developed in subsequent portions of this report. The Tire category includes passenger, truck and large tractor tires and the Other category includes all the remaining rubber items such as innertubes, garden hose, hot water bottles, mats, windshield wiper blades.

Also included in TABLE II-1 is the product distribution per capita and per square mile of each state area. This is an indication of each individual state's disposal problem particularly by land-fill; from a high of 41,650 pounds per square mile per year for New Jersey, neglecting the 677,970 pounds per square mile for Washington, D.C. to a low of 20 pounds per square mile per year for Alaska, where land is undoubtedly less expensive than in New Jersey. It is interesting to note the higher per capita usage of rubber products in the predominantly rural areas of for example Wyoming, 72.4 pounds per capita per year and Montana, 70.1. This is primarily due to the large number of farm implements owned by residents in addition to the automobile and usual home rubber products and to the low density of population and consequent greater motor vehicle use per capita to participate in the daily life of a typical community.

These figures are not adjusted for the waste consumed by the major converters. They do not include the retreaded tires which are being recycled in the amount of 1.6 billion pounds in 1968 compared to total new tires of 6.0 billion pounds. While the 1.6 billion pounds are not disposed of in 1968, tires recapped in previous years will be, therefore the overall net waste is considered to be the 6.0 billion pounds. It can be assumed that the Retreaders are uniformly distributed over the country. However, the next largest consumer, the Reclaimers are not uniformly distributed, with a high concentration in the Ohio and Northeastern sections. Since waste converted by them is normally not drawn from distant points, it therefore seems logical to assume, since accurate data could not be developed, that the waste disposal problem in these areas is reduced. A listing of Reclaimers is noted in Section III.

The third largest consumer, the Parts Industry, although small by comparison, is mainly located in the Chicago-St. Louis areas.

Another method of analyzing the distribution data clearly emphasizes the logistical problem in collecting the rubber product waste. In Fig. II-1 the United States is subdivided into standard census geographic areas. The circles within these areas represent groups of metropolitan districts with a 100 mile radius whose total rubber product usage is at least 1% of the nation's total, each one percent equivalent to 100 million pounds per year. Percentages shown within the circles do not include usage in rural or small towns within the circle, which is included in the total percentages for the specific geographical area. It is noted that 51% of the waste is included within the 20 circles with the remaining 49% thinly spread over the remaining areas. The mid-Atlantic axis (Boston-Wilmington) accounts for about 15% of the total. The mid-West axis (Milwaukee-Chicago-Detroit-Cleveland-Pittsburgh) accounts for about 9%. The remaining two-thirds of the waste however is widely distributed over the remaining isolated metropolitan circled areas or the rural-small town areas in between.

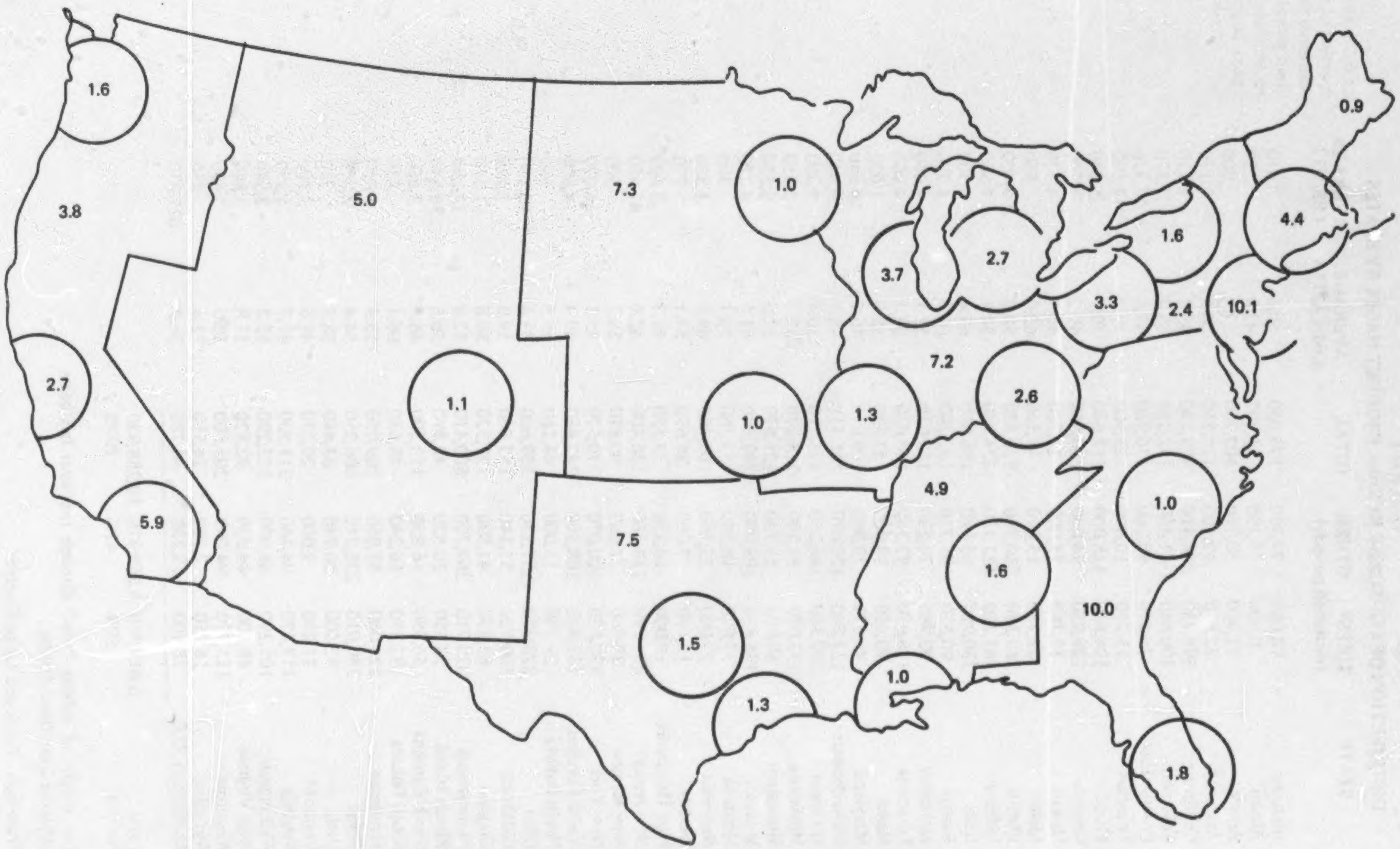

1.6
3.8
5.0
7.3
1.0
0.9
4.4
1.6
2.7
3.7
3.3
2.4
10.1
7.2
2.6
2.7
1.1
1.0
1.3
4.9
1.0
5.9
7.5
1.6
10.0
1.5
1.0
1.3
1.8

FIGURE II-1 GEOGRAPHICAL PERCENT DISTRIBUTION OF WASTE RUBBER

The number indicates the percent of the nation's waste rubber located within the cirlce. The remaining numbers indicate the percent waste rubber located outside the circles but within the bordered areas.

TABLE II-1
DISTRIBUTION OF CONSUMER RUBBER PRODUCT WASTE BY STATES

STATE	TIRES*	OTHER	TOTAL	AVERAGE LBS/CAPITA	AVERAGE LBS/M12
	(thousand pounds)				
Alabama	98,060	77,790	175,850	50.6	3,410
Alaska	6,600	5,390	11,990	45.0	20
Arizona	71,960	30,770	102,730	57.7	900
Arkansas	72,850	42,300	115,150	56.5	2,170
California	598,730	374,410	973,140	49.7	6,130
Colorado	100,860	41,460	142,320	65.7	1,370
Connecticut	76,670	60,260	136,930	47.6	27,336
Delaware	15,210	10,690	25,900	49.2	12,590
Florida	194,640	118,000	312,640	50.7	5,340
Georgia	126,020	94,030	220,050	49.2	3,740
Hawaii	12,760	15,000	27,760	40.7	4,320
Idaho	29,730	15,810	45,540	62.0	550
Illinois	289,330	240,200	529,530	50.0	9,400
Indiana	163,220	111,130	274,350	54.5	7,560
Iowa	130,990	65,820	196,810	67.4	3,500
Kansas	90,570	51,720	142,290	60.3	1,730
Kentucky	90,780	72,230	163,010	52.1	4,040
Louisiana	116,670	77,360	194,030	52.4	4,000
Maine	30,650	23,080	53,730	55.8	1,620
Maryland	95,670	73,940	169,610	46.7	16,040
Massachusetts	123,740	122,670	246,410	48.1	29,840
Michigan	239,360	186,350	425,710	50.4	7,300
Minnesota	133,070	81,200	214,270	58.3	2,550
Mississippi	69,800	51,720	121,520	52.2	2,550
Missouri	194,830	103,000	297,830	61.5	4,270
Montana	37,020	16,240	53,260	70.1	360
Nebraska	73,000	33,760	106,760	69.2	1,380
Nevada	19,650	7,000	26,650	53.1	270
New Hampshire	19,000	14,530	33,530	49.8	3,600
New Jersey	181,940	114,460	326,400	47.6	41,650
New Mexico	37,960	22,650	60,610	58.7	500
New York	370,520	400,050	770,570	45.1	16,070
North Carolina	133,900	108,560	242,460	49.4	4,600
North Dakota	29,260	15,000	44,260	65.5	630
Ohio	328,370	231,230	559,600	53.4	13,580
Oklahoma	100,720	55,140	155,860	59.8	2,230
Oregon	85,430	41,890	127,320	59.8	1,310
Pennsylvania	330,710	269,700	600,410	52.8	13,244
Rhode Island	23,350	20,520	43,870	50.5	36,140
South Carolina	56,650	56,850	113,500	46.6	3,650
South Dakota	32,390	16,240	48,630	68.1	630
Tennessee	124,000	85,050	209,050	53.4	4,950
Texas	380,010	228,240	608,250	54.4	2,280
Utah	42,500	20,940	63,440	58.3	750
Vermont	11,230	9,000	20,230	49.6	2,100
Virginia	117,470	94,460	211,930	47.7	5,190
Washington	105,290	68,000	173,290	55.2	2,540
West Virginia	48,800	44,020	92,820	53.8	3,840
Wisconsin	111,770	94,030	205,800	50.6	3,670
Wyoming	16,850	7,700	24,550	72.4	250
Washington, D.C.	28,400	18,380	46,780	56.9	677,970
Total	6,018,960	4,269,970	10,288,930		
Percent	59%	41%	100%		

The weight of rubber "lost" through tire wear has been deducted from these figures.

*Passenger, Truck and Large Tractor.

COLLECTION OF CONSUMER RUBBER PRODUCT WASTE

Aside from automotive tires and innertubes, there is apparently little other segregated collection of the nation's worn rubber articles. Tires and innertubes are collected or accumulated mainly by tire stores, gasoline stations, fleet operators, and retreaders. When a tire is worn out, it is usually changed or replaced by a new tire at one of these commercial operations. Few tires are replaced by motorists themselves. This practice normally results in tire accumulations at convenient pick-up points. In areas where tires are a disposal problem, however, it is a common practice for the station attendant to put the worn tire back into the trunk of the customer's auto and the tire ends up unsegregated in the residential solid waste. When innertubes are no longer required they are usually saved by the motorist against the day when he may need it again for a leaking tire, for a swimming tube, or for a use to be determined. It invariably ends up later in residential waste.

Almost all other types of rubber waste (excluding rubber waste from the rubber industry) from worn rubber products are easily disposed of in mixed waste. For example, discarded rubber gloves, boots, mats, floor coverings, cart or transporter tires and wheels, power drive belts, wire, and others are disposed of indiscriminately. Small scrap articles of this type are easily discarded in mixed trash. Tires, however, are not so easily discarded and are usually collected separately. By comparison, waste from the rubber products industry, in the form of selvage or rejects, is more easily collected in segregated, re-usable form. Most manufacturers, with economic incentive, make concerted efforts to lower their costs by selling this segregated waste to reclaimers or other industries which can use them.

Scrap rubber must be collected in a controlled way to be efficiently reclaimed. The bulk of rubber waste that is reprocessed today is collected by local used-tire merchants. These merchants purchase worn out tires and tubes and manufacturer's rejects and scrap. The used-tire merchant sells reusable casings to retreaders and the remainder to scrap rubber brokers. Brokers operate on a national and international scale, purchasing scrap rubber from merchants and making volume sales to reclaimers and other waste rubber consumers. This system permits the waste consumer to buy in large quantities at fairly stable prices from established brokers instead of bartering with a number of small merchants. Having determined their usual requirements, reclaimers and other purchasers will usually place standing orders with brokers who will further place orders with merchants.

A typical example of a haphazard, costly collection of waste rubber is probably exemplified by the victory rubber drive of World War II. Although many millions of pounds were collected, only a small quantity could be reclaimed. Rubber boots with straps or buckles and bicycle wheels, for example, were difficult to separate from the contaminating metals and serious production problems arose from inadequate sorting. Other than the tires and innerturbes collected it is reported that substantial quantities of mixed wastes were discarded after the emergency was over; the economics precluded any future use.

PRESENT REUSE OF WASTE RUBBER

The area of significant usage of waste rubber products, and incidentally also scrap from the rubber product industry, occurs in three major industries Retreaders, Reclaimers, and Tire Splitters. Retreaders, the largest of the three, extend the useful life of worn tires by placing new tread on the old carcass. The second largest, the Reclaimers, after removing non-rubber components such as metal and fabric, convert the rubber into a reusable form so it may be worked back into conventional rubber products. The Tire Splitters cut out small rubber parts mainly from the carcass and tread areas of waste tires. These three significant industries consumed waste in 1968 approximately equal to 20% of the new rubber products produced in that year.

Table II - 2

WASTE RUBBER USED AND AVAILABLE: 1968

		Billions of Pounds	Percent
Tread Loss (Tire Wear)*		0.43	4.02
Waste Rubber Reused by:	Reclaimers	0.54	5.05
	Retreaders	1.56	14.58
	Tire Splitters	0.05	0.47
Total Weight Reused or Worn Away		2.58	24.12
Weight of Waste Rubber Left for Disposal		8.12 **	75.88
Total		10.7 ***	100.0

*Through oxidation and wear of tires on the nation's highways (approximately 8 lbs. per year per driver) 434,000,000 lbs. of rubber polymer were converted to dust and gas.

**Does not include weight of tires retreaded in previous years which were discarded in 1968. Does not include waste accumulated and not disposed of in previous years.

***Consists of approximately 10.7 billion pounds of discarded products and 0.4 billion pounds of rubber products industry waste rubber compound.

A more detailed breakdown, based on the two waste categories of tires and other, is more specific as to the quantities of each category consumed by the three waste users and also includes new waste generated to arrive at the overall net effect of these industries. TABLE II-3

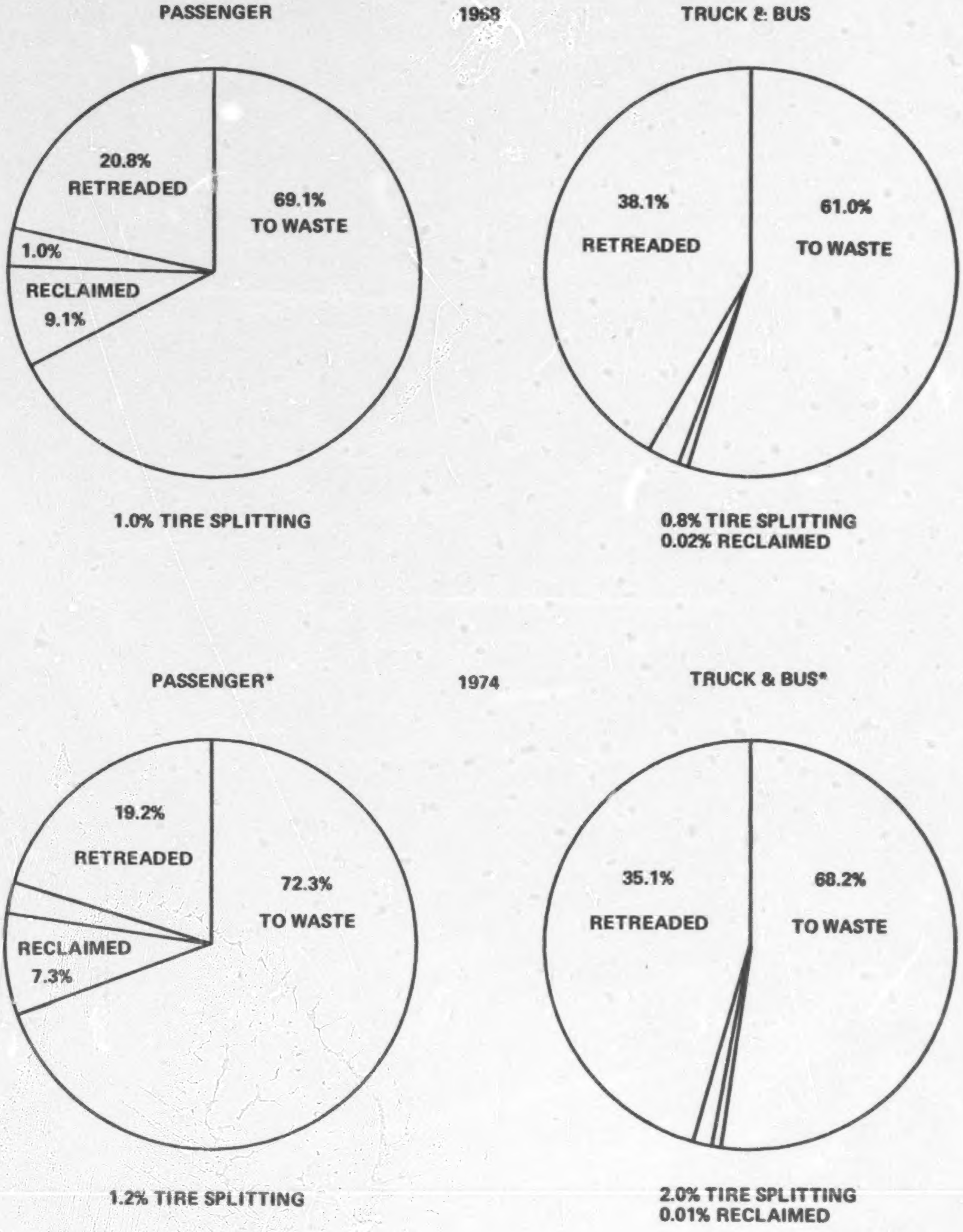
For tire waste, 1.95 billion pounds are collected out of the total of 6.02 billion pounds available, of which 1.80 billion pounds are used or sold to other uses. There are 0.20 billion pounds of collected tires unsuitable for reuse for various reasons and which are returned to waste. Approximately 0.02 billion pounds of new waste are created during the waste conversion. The net effect of this reuse is a waste reduction from 6.02 billion pounds per year to 4.24 billion pounds, a 30% reduction.

With the projected increase in tire production and little if any increase in waste tire usage, the percent tire waste used is expected to decrease from 35% in 1968 to 33% in 1974, excluding the new waste created by the three users. Figure II-2

TABLE II-3
TIRE AND OTHER WASTE REUSE
(billion pounds)

	TIRES			Sub-Total	OTHER	Sub-Total	TOTAL
Rubber Waste Available				6.02		4.27	10.29
	Reclaimers	Retreaders	Splitters		Reclaimers		
Collected for Reuse	0.30	1.60	0.05	1.95	0.12		
Reject to Waste	0.06	0.13	0.01	0.20	–		
New Waste Created	0.01	0.01	–	0.02	–		
Reused or Resold	0.20	1.56	0.04	1.80	0.12		

FIGURE II-2 DISCARDED TIRE DESTINATION



*Based on the production of 220 million passenger tires

*Based on the production of 32.5 million truck tires.

BLANK PAGE

Section II
The Reclaimed Rubber Industry

Preceding page blank

HISTORY OF THE RECLAIMED RUBBER INDUSTRY

The rubber reclaiming industry has always followed scientific developments in the raw rubber industry with developments of its own. It was not long after rubber trees were commercially tapped and dry rubber marketed that a method was devised to solvate waste latex and put it back to good use. Later, Sir Thomas Hancock, father of the United Kingdom's rubber industry, devised a horse driven machine which resolved all his waste rubber into a solid mass by pressure and heat. This enabled him to return the waste back into the elastic thread he was producing at the time. In 1839, the foundation of present rubber technology came into being when Charles Goodyear discovered vulcanization. Prior to this development, rubber items were very responsive to weather. They became soft and sometimes smelly in hot weather and rigid and inflexible in cold weather. Vulcanization, or the treatment of rubber with heat and a curative, i.e. sulfur, produced a practical rubber product with none of these drawbacks.

A mechanical method for reclaiming rubber now came into being and articles which did not contain fabric or very little fabric were ground up and used as filler in new rubber. Car springs, large molded blocks of rubber used in journal boxes of horse cars, were a source of fabric free rubber and even today, "ground spring" is a term used to describe any ground up fabric free rubber.

In 1870, W.N. MacCartney heated ground scrap with a solvent until the rubber dissolved. One of the first reclaims was produced upon evaporation of this solvent. Even earlier, in 1846, Alexander Parks boiled waste in Muriate of Lime. Both these methods fell to the background while the easier mechanical process, suitable for its time, predominated. Following the mechanical method the next major development was Hiram L. Hall's Heater or Pan Process. The patent was issued in 1858. Hall ground the rubber and placed it in shallow pans. The pans were now placed in a closed vessel where steam was directed onto the rubber. Although, not stated, it is believed that he also added oils to help in the heat transfer. The Pan Process was relatively simple. With little machinery required, a good reclaim could be made and today approximately 34% of all reclaim in the United States is made in this manner.

The "ground scrap" Hall used was essentially fabric free. It came from rubber boots and shoes, the largest rubber commodity available at that time. Family incomes were supplemented by women and children, who pulled rubber from the fabric at home and later sold it to reclaimers. Rubber footwear production, at an annual rate of 1 million pairs in 1840, was to rise to 50 million by 1900. The scrap supply was changing, however. In 1900 carriage tires and solid rubber truck tires appeared. Later, in 1905, the pneumatic tire appeared. Tires, reinforced with fabric, carbon black and heavier cures, became predominant. The foremost problem was fabric. The stripping of rubber from fabric by hand was now becoming impractical. Tires, the new major sources of scrap, forced reclaimers to look for new and better ways to recover the rubber. A new and better way had been found much earlier however, by a young man named Eugene H. Clapp. Mr. Clapp in 1868, had developed and set up a small apparatus for separating fiber by means of air. Briefly the whole rubber article was ground up and subjected to an air blast. Here, the lighter, more responsive fabric "blew away" from the heavier solid or nearly solid rubber particles. Machinery was not developed during those years to make use of Clapp's idea. Today his air separation principle combined with fine grinding is widely used for fabric removal. In 1873, Guggenheim and Lowry treated rubber waste with an 8-10% caustic solution to destroy any wool present. After washing, they treated the scrap with 15-20% sulfuric acid solution to destroy any cotton. The resultant reclaim was of poor quality.

In 1881, Colonel N. Chapman Mitchell secured a patent for the Acid Process. Essentially he boiled the ground rubber scrap in a 20% sulfuric acid solution which destroyed any cotton and/or wool fabric present. Afterwards the ground scrap was washed, dried, heated with oils and milled. A study of the history of reclaiming will show that many people had done work with caustic and sulfuric acid solutions and as a result of prior work of others and improperly drawn patents Mitchell was dragged into long and costly litigation. He did, later on, form the first company organized exclusively for the production of the acid process reclaim. His process was used primarily for rubber goods of low sulfur content. The acid process was impractical for scrap high in sulfur such as tires. The excess sulfur in tires and other goods could not be removed by the acid but, on the contrary, would combine chemically with the rubber during the heating process in open steam with the result that further vulcanization instead of devulcanization would occur. Because of this, a contemporary development, the Alkali Process would become the single most successful method of the time. Arthur H. Marks patented this process in 1899. The process involved the heating of ground rubber waste with a 3 to 16% caustic solution at 344-370°F for twenty hours. The sulfur in the scrap dissolved into the caustic solution and any fiber present was destroyed. The heating was carried out in an apparatus specified in the patent. It consisted of a closed vessel contained in another vessel into which steam was introduced Defiberization, desulfurization and devulcanization were completed in one step with this process. The next year Marks received a patent for a horizontal, rotating digester which except for a few changes, is essentially the apparatus used to produce 58% of the reclaim in the United States today.

This leads us to the last major development in the early years of reclaiming. Robert Cowen was issued two patents in 1900 on the strainer. A rubber strainer is similar to the meat grinder a butcher uses today to produce the strands of ground meat sold in markets. Prior to its manufacture, all contamination had to be picked out by hand creating a bottleneck in production. Forcing the rubber through a screen which held back contaminants enabled the reclaim industry to improve production considerably.

The development of the synthetic rubber industry in the United States forced reclaimers to do considerable research on the reclaiming of blends of different rubber polymers. Prior to synthetic rubber development, natural rubber was the only polymer present. This rubber could be reclaimed by heat alone. Heat however, tends to harden most synthetic polymers. Also, the methods of grinding the scrap had to be revised since natural rubber absorbs oils and reclaiming catalysts much faster than synthetic rubber, the natural rubber part of the reclaim will be more depolymerized than the synthetic and the final reclaim will be nonhomogeneous. To overcome this the rubber mixture is now ground to a smaller particle size in order to present a larger surface area for absorption. Eventually, certain diterpenic acids were found which, in general, retarded the oil absorption of vulcanized natural rubber scrap and thereby permitted a more uniform distribution of reclaiming oils in the scrap components. Finally, the use of caustic or alkali solutions as defibering agents was almost totally eliminated as caustic hastened the heat hardening of SBR rubber and other synthetics. As a result, the neutral process is now used for defibering employing metal chlorides such as zinc or calcium for the removal of fabric.

THE RECLAIMED RUBBER INDUSTRY

The members of this industry, more commonly known as "Reclaimers", for the purposes of this report, are limited to those who are predominantly concerned with the conversion of used or rejected rubber products into re-usable materials. These materials are usually reused in the same or products similar to those from which they were "reclaimed" i.e. scrap tires are reclaimed and converted to a soft workable state wherein they are capable of being blended into tire compounds for new tire manufacture. It is also inherent in the reclaimed rubber industry, that some materials are produced which are not reused in the rubber industry but in other industries. Some examples are adhesives, wire covering, pipe covering, brake linings rubberized asphalts and tars. However, this is a small portion of a "Reclaimers" operations.

There are fourteen rubber reclaiming companies in the United States operating twenty individual plants, with a reported employment of 1812 people (Table II-4). Recently two of these plants were reported closed and another is rumored to be closed in the near future. Most "Reclaimers" are also members of the Rubber Reclaimers Association (RRA). The RRA reported an overall capacity of 825 million pounds per year in 1968. Historical production in pounds and as a percent of 1968 capacity is noted and graphed in TABLE II-5. The two plants reported to have closed recently further reduce the capacity reported in 1968. Previous years capacity is also known to have been somewhat larger but was reduced to the 825 million pound figure by the closing of two major plants, one in California and the other in New York. The geographic distribution of the remaining eighteen plants is mapped in Figure II-3 and indicated a similarity to the distribution of the rubber producers.

TABLE II - 4

RECLAIM

PLANT LOCATIONS

1. H.Muehlstein and Co.
   Jersey City, N.J.
2. Uniroyal Chemical Div. Uniroyal, Inc.
   Naugatuck, Conn.
3. Boston Woven Hose and Rubber Div., American Biltrite Rubber Co., Inc.
   Cambridge, Mass.
4. Biltrite Rubber Co., Inc.
   Stoughton, Mass.
5. U.S. Rubber Reclaiming Co.
   Vicksburg, Miss.
6. Midwest Rubber Reclaiming Co.
   E. St. Louis, Ill.
7. Midwest Rubber Reclaiming Co.
   Chester, Pa.
8. Midwest Rubber Reclaiming Co.
   Barberton, Ohio
9. Centrex Corp.
   Findlay, Ohio
10. Gates Tire and Rubber Co.
    Denver, Colo.
11. Goodyear Tire and Rubber Co.
    Akron, Ohio
12. Goodyear Tire and Rubber Co.
    Gadsden, Alabama
13. Laurie Rubber Reclaiming Co.
    New Brunswick, N.J.
14. Nearpara Rubber Co.
    Trenton, New Jersey
15. Swan Rubber Co., Div. of Amerace Corp.
    Bucyrus, Ohio
16. Bearfoot Sole Co.
    Wadsworth, Ohio
17. Xylos Rubber Co., Div. of Firestone Rubber Co.
    Memphis, Tenn.
18. Xylos Rubber Co., Div. of Firestone Rubber Co.
    Los Angeles, Calif.

19. Xylos Rubber Co., Div. of Firestone Rubber Co.
Akron, Ohio

20. B.F. Goodrich Industrial Products Co.
Akron, Ohio

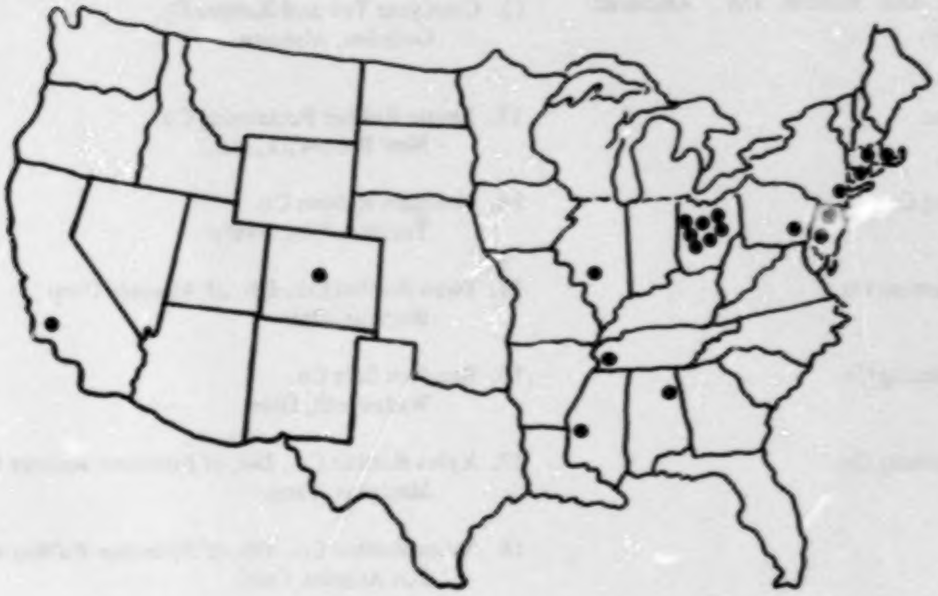
TABLE II - 5

The United States Production of reclaimed rubber is listed below as a percentage of the total capacity of the industry.

YEAR	PRODUCTION (million pounds)	PERCENT OF PRODUCTION CAPACITY
1958	581.5	70.3
1959	457.3	55.3
1960	655.9	79.2
1961	591.0	71.0
1962	628.4	75.6
1963	630.4	76.0
1964	618.8	75.0
1965	627.8	75.5
1966	621.3	75.0
1967	545.8	65.7
1968	575.0	69.3
1969-1974	560.0 (est.)	(67.5) (est.)

FIGURE II-3

The location of the twenty reclaiming plants presently in the United States are shown below:



RUBBER WASTE INPUT

Reclaimers use two categories of waste: those items reported in Part I as Rubber Products and whose useful life is completed and some scrap items of the Rubber Products Industry. In the latter category are included defective manufactured items, selvage, cleanouts, etc. These were not reported as original waste in Part I as they are normally disposed of directly to a reclaimer or to independent agents selling to reclaimers. A breakdown of the reported Reclaimers 1968 usage in these categories indicates 43.7% usage of rubber product waste and 7.5% of producers waste as shown in TABLE II-6. The balance of 48.8% consumed was not reported by composition but is known to be a mixture of both categories. It can undoubtedly be assumed that the total industry usage is in the ratio of 43.7% to 7.5% of product waste to producers scrap.

TABLE II - 6

1968 RUBBER WASTE USAGE BY RECLAIMERS

DESCRIPTION		
WASTE RUBBER PRODUCTS	**WEIGHT (million pounds)**	
Worn Tires		
Passenger	141.1	
Truck, Bus, Tractor	.2	
Retread Buffings*	.1	
Tire Parts, Peelings*	8.2	
Other Tire Parts	39.8	
Inner Tube – Natural Rubber[1]	9.5	
Inner Tube – Butyl Rubber	53.5	
Sub-Total	252.4	43.7%
Rubber Manufacturing Scrap		
Rejected Tires*	23.9	
Mechanical Product Scrap	11.2	
Other*	.3	
Raw Polymer*	7.6	
Sub-Total	43.0	7.5%
Other Rubber Consumed[2]		
Sub-Total	281.1	48.8%
Grand Total	576.5	100.0%

*Definitions listed in Appendix 1.

[1] Poundage shown contains a small quantity of factory rejects for which there is no separate data.

[2] Composition not reported but known to be a mixture of worn products and manufacturer's by-products.

Road worn tires are generally available in sufficient quantity within 300 miles of individual reclaim plants. This does not apply to the concentration of plants in the Ohio area. The delivered cost of tires may vary from $7-14 per ton depending on freight costs.

Tires other than passenger types, such as truck, bus, and off-the-road are also generally available in quantity with the delivered cost being approximately equal to the passenger tire. Reclaim usage of these larger types is small however, due to the added handling and processing costs.

Retread buffings are readily available as a source of ground rubber without fiber. The cost is approximately $25-35 per ton depending on freight charges.

Tire parts are a by-product of the Splitting Industry. They are a good source of fabric free tire treads or "peelings". Tire carcass selvage has value approximately equal to worn tires. Natural rubber innertubes are restricted in availability as production of these tubes is now limited. Due to demand for this type reclaim for adhesives, scrap prices are $120 to $160 per ton. Considerable quantities of this scrap are imported to meet the demand. Butyl rubber innertubes, more available than natural tubes, are at a slightly lower cost of $100 to $120 per ton. Considerable quantities of butyl rubber tubes are also imported to fill demand. Scrap collection costs and procedures for both types of tubes restrict higher use of domestic scraps.

Most producers scrap tires are directly shunted to reclaimers at a price comparable to price of worn tires. Without exception this is the case where the tire manufacturers have an internal reclaim plant. Only steel reinforced tires and tires with safety barriers are discarded as these are too difficult to reclaim with existing equipment.

Other than road worn tires and innertubes, little, if any, other used consumer type rubber products are collected and reprocessed by reclaimers. Any consumer type rubber products which are used consist mainly of factory rejects and selvage types which are picked up at the factory. Only in this manner can collection costs be held down and products grouped into categories which can be handled and processed by the reclaimers into suitable reclaims, i.e. two different items such as a rubber mat and a hot water bottle may require different reclaiming chemicals and processes. Prices for scrap depend largely on type, color and transportation costs and will vary from $15 to in excess of $100 per ton.

Sophisticated elastomeric polymer products such as those made from silicones and fluoroelastomers, are presently small in comparative volume. Availability is again restricted to the factory reject type of scrap. More particularly here, cross contamination with other types of polymers would be particularly disastrous negating many of the advantages of reclaiming these types of polymers. Due to their specialized nature, these polymers are usually reclaimed on consignment for the company supplying the scrap.

Raw polymers as a by-product from polymer producing plants are available in considerable quantity. Costs vary depending upon the type and transportation.

INDUSTRY SOLID WASTE

Since the Reclaim Industry normally literally "feeds" on waste, the solid waste produced by the reclaim industry itself consists of that portion of the original waste which cannot be converted into a reusable product.

During 1968, the Reclaim industry converted approximately 576 million pounds of waste rubber products and Rubber Product Producer waste into approximately 574 million pounds of saleable, reusable products. During the conversion, 75 million pounds of solid waste were generated. The majority of this waste, however, consisted of nonrubber components removed from the waste taken in.

TABLE II-7 summarizes the sources of solid wastes generated by the Rubber Reclaiming Industry itself and FIGURES II-4,5,6 illustrate the sources of these wastes in the three major reclaiming processes as well as the flow of materials thru these processes.

The weight of oils and compounding ingredients which were later added into the rubber product to assist production and meet customer needs, nearly equaled the weight of nonrubber and waste components removed.

UNCONVERTED WASTE (62 million pounds)

Thirteen million pounds of ferrous and nonferrous scrap metals were removed from the waste rubber taken in. The ferrous metals, mainly the steel bead wire from tires, may be reused during periods of need and high scrap steel value. The need has presently been reduced, partially by the new technology of steel production.

The nonferrous scrap has been more readily reused. The copper innertube stem scrap which is the predominant nonferrous scrap, having a higher value, is more easily reused. The weight of textile and textile-rubber mix separated from the original waste came to 37 million pounds in 1968.

The textile fibers partially separated from worn tires are usually a mixture of all types of fibers used in tire manufacture. This will include rayon, nylon, polyester and glass with a small amount of cotton. As new fibers are introduced into tire manufacture, they will show up in the textile mix.

Due to the mixed nature of the textiles, the amount of entrained rubber carrying over, and the short length of the fiber normally coming from conventional fiber separation equipment, the mix has little value for reprocessing. It may have some value or usage potential in nonwoven mat applications i.e. insulating board. Another considered area is as an agricultural mulch.

The waste rubber discarded (12 million pounds) is predominantly unusable scrap tires consisting of the studded snow tire or steel wire belted types. These are sorted from shipments of worn tires and discarded. It is highly doubtful that development of methods to convert these into reclaims would effectively reduce waste.

NEW WASTE (13 million pounds)

Packaging material waste amounted to 8 million pounds in 1968. Packaging waste is usually reduced by bulk handling of all materials and by reusable containers. These aspects of material handling are beyond the scope of this report.

Other scrap (5 million pounds) involves office paper, pallets, strapping and miscellaneous items which are typical in many other industries.

TABLE II - 7

RECLAIM INDUSTRY SOLID WASTE - 1968

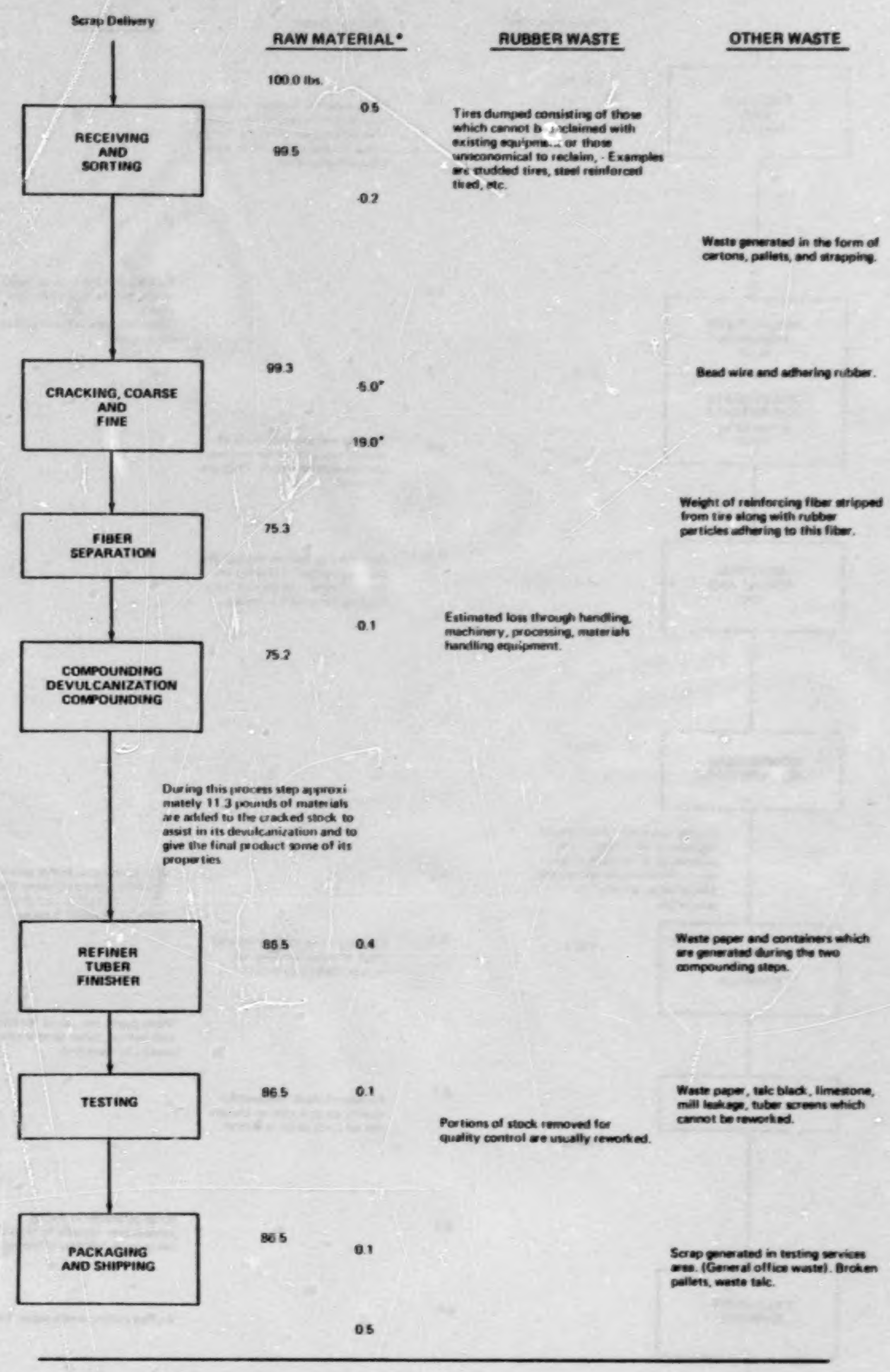
Description	**Weight (Million Pounds)**	**%**
From Original Waste		
Ferrous & Non Ferrous Metals (a)	13.2	17.6
Textile & Textile-Rubber Mix (b)	37.1	49.3
Rubber (c)	11.6	15.4
Sub-Total	61.9	82.3
New Waste		
Packaging Materials	8.0	10.7
Other	5.3	7.0
Sub-Total	13.3	17.7
GRAND TOTAL	75.2	100.0%

(a) Predominantly ferrous bead wire from tires, remainder mainly nonferrous value stems from natural and butyl tubes.

(b) Textiles and Textile-Rubber mixtures predominantly from processes using mechanical separation of textiles from rubber. Source mainly from tires.

(c) Predominantly worn tires which cannot be suitably reclaimed, i.e. studded winter snow tires and steel wire re-inforced tires.

FIGURE II-4 DIGESTER OR WET PROCESS


Scrap Delivery
RAW MATERIAL*
RUBBER WASTE
OTHER WASTE
100.0 lbs.
0.5
RECEIVING AND SORTING
99.5
0.2
99.3
5.0*
CRACKING, COARSE AND FINE
19.0*
FIBER SEPARATION
75.3
0.1
75.2
COMPOUNDING DEVULCANIZATION COMPOUNDING
REFINER TUBER FINISHER
86.5
0.4
TESTING
86.5
0.1
PACKAGING AND SHIPPING
86.5
0.1
0.5

Tires dumped consisting of those which cannot be reclaimed with existing equipment or those uneconomical to reclaim, - Examples are studded tires, steel reinforced tired, etc.

Waste generated in the form of cartons, pallets, and strapping.

Bead wire and adhering rubber.

Weight of reinforcing fiber stripped from tire along with rubber particles adhering to this fiber.

Estimated loss through handling, machinery, processing, materials handling equipment.

During this process step approximately 11.3 pounds of materials are added to the cracked stock to assist in its devulcanization and to give the final product some of its properties.

Waste paper and containers which are generated during the two compounding steps.

Waste paper, talc black, limestone, mill leakage, tuber screens which cannot be reworked.

Portions of stock removed for quality control are usually reworked.

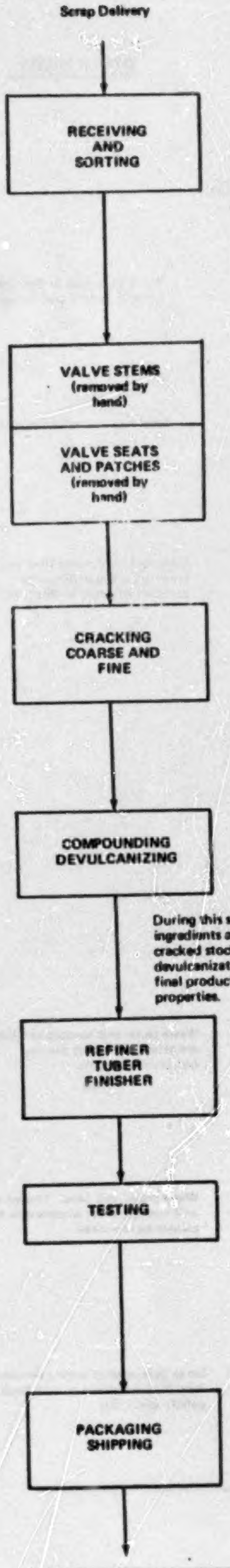
Scrap generated in testing services area. (General office waste). Broken pallets, waste talc.

TOTAL PRODUCT	86.5 lbs.

0.6 lbs. RUBBER WASTE
25.3 lbs. OTHER WASTE

*If the raw material does not contain any reinforcing fabric or metal, this weight (5.0 + 19.0 lbs) will be deducted from the OTHER WASTE total and added with additional compounding ingredients to the total product weight.

FIGURE II-5 PAN OR DRY PROCESS


Scrap Delivery
RECEIVING AND SORTING
VALVE STEMS (removed by hand)
VALVE SEATS AND PATCHES (removed by hand)
CRACKING COARSE AND FINE
COMPOUNDING DEVULCANIZING
REFINER TUBER FINISHER
TESTING
PACKAGING SHIPPING

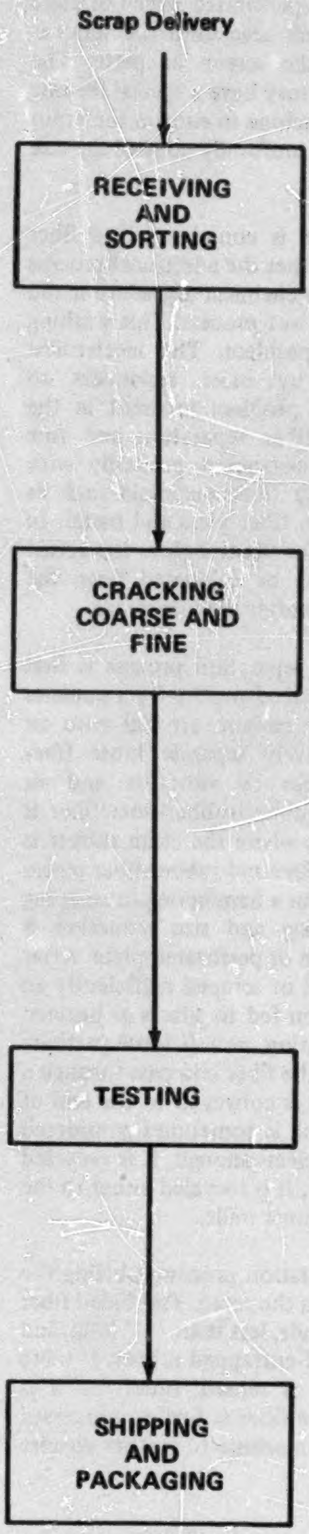
Raw Material*		Rubber Waste	Other Waste
100.0 lbs			
99.0	-1.0	Stock which is dumped. It consists of scrap which cannot be reclaimed with existing equipment or scraps which have deteriorated or have been contaminated.	
	-0.2		Packaging waste such as metal straps, pallets, and cardboard boxes. Stems are removed and sold as scrap metal.
97.4	-1.4		
96.9	0.5	Patches and seats are made of several types of rubber and may contaminate the stock. They are dumped.	
96.7	-0.2	Raw stock is flushed through the cracking system to remove any contaminants. The contaminated flushing material is dumped.	
104.4			
During this step, 7.7 pounds of ingredients are added to the cracked stock to assist in the devulcanization and to give the final product some of its properties.	0.2		Waste generated in this section. It consists of empty paper bags, cartons, and other containers, a majority of which is paper.
104.3	-0.1	Estimated loss of devulcanized stock through handling, i.e. bucket loaders, conveyors.	
	0.1		Waste paper, talc, black limestone, mill leakage, tuber screens which cannot be reworked.
	-0.1	Portion of stock removed for quality control testing. Usually not set aside to be reworked.	
104.2			
	0.1		Scrap generated in testing services area. Usually in form of waste paper (general office waste).
	0.4		Broken pallets, waste paper, talc.

TOTAL PRODUCT 104.2 lbs.

1.9 lbs. = RUBBER WASTE
2.4 lbs. = OTHER WASTE

*The raw material used in this example consists of inner tubes.

FIGURE II-6 RUBBER CRUMB PROCESS



Raw Material*		Rubber Waste	Other Waste
100.0 lbs.			
	-0.7	Stock loss usually due to deterioration or discoloring of material, contamination, or discontinuance of product line.	
99.3			
	-0.2		Waste generated in form of waste paper, wire strapping, broken pallets, etc.
99.1			
	-0.2	Raw stock is flushed through the system to remove any contamination. This flushing material is discolored and/or contaminated and cannot be used. It is dumped.	
98.9	-0.1	Estimated loss through machinery and materials handling equipment.	
98.8			
	-0.1	Portion of stock removed for quality control testing.	
	0.1		Scrap generated in testing services. (Usually in form of general office waste)
98.7			
	0.1		Broken pallets, waste paper, talc, strapping.

TOTAL PRODUCT 98.7 lbs

1.1 lbs. = RUBBER WASTE
0.4 lbs. = OTHER WASTE

*** The raw material used in this chart consists solely of rubber polymer which does not contain any reinforcing fabrics or metals. If the raw material selected does contain metal or fabric then the weight of this material must be deducted from the final product weight and this separated metal or fabric becomes other waste.**

THE RECLAIMING PROCESSES

An indication of the state of technological development of the reclaims industry can be obtained from a study of the reclaim processes. The following processes are itemized in chronological order of events leading to the reclaiming of waste rubber. However, not all reclaimers may use all of these processes nor the same equipment. The individual process and its equipment may vary from company to company but the end result is comparable. Items such as product blowers, conveyors, manpower, numbers of machines and their productivity, in-plant trucking, storage areas, inspection stations, cleaning and maintenance stations are not included but are assumed to be required at the discretion of the reclaimer.

The three basic processes used are digester (wet), devulcanizer (dry) and mechanical. A generalized material flow pattern for each process indicates the differences between each (Figure II-7). All three processes do contain some common steps and process equipment. The first step is to separate the many wastes into four basic streams such as tires, tubes, mechanical scrap and miscellaneous. Part of this step includes the removal of the brass and steel valve stems from the tubes and these stems are either sold or discarded as waste. Also, the bead wire from the tires is removed and discarded as waste. These metals were once more widely sold as recoverable waste. The metal removal is usually done manually but some bead wire is removed by machine.

After separation, the wastes are size reduced, through two basic types of machines, crackers or hammer mills. The cracker is a two roll machine, having working roll lengths of 30" to 42" and diameters of 18" to 32" depending upon the individual reclaiming company. Each roll is corrugated or fluted axially and each roll rotates at a different speed to effect a friction ratio. As the waste is dropped into the cracker, the two rolls, which rotate in opposite directions, force the waste to pass between them. The slower roll corrugations momentarily "hold" the waste while the faster roll corrugations shear, slice, crush and abrade the waste much like a pair of scissors. The process continues until all the material passes through a classifying screen of some predetermined size. Some reclaimers further reduce the waste size down to less than 10 mesh having secondary and tertiary crackers. As the size of the waste becomes smaller, the corrugations or flutes on the cracker rolls become smaller and smaller to increase the grinding efficiency. If tires are the waste material, the separated bead wire which serves to hold the tire firmly to the rim of the automotive wheel, is removed by hand after two or three passes through the crackers unless the bead wire was cut out before the size reduction process. The action of the two rolls actually peels or scrapes the rubber off the wire, leaving only residual amounts with the metal. The bead wire is then scrapped.

The term hammer mill covers a family of several machines, in essence a high speed rotating drum which either hammers or impinges the scrap with pivoting "T" or "I" bars or with knives mounted on the periphery of the drum. There may be stationary knives located on the frame within which the drum revolved, with or without a perforated screen or plate that retains the scrap in the work area until the scrap is size-reduced to pass through the screen or plate. The machine containing drum knives, may have a special feeding device at the inlet side of the machine to control the input feed of a long strip or the like, to uniformly control the size of slicing much like a meat slicer.

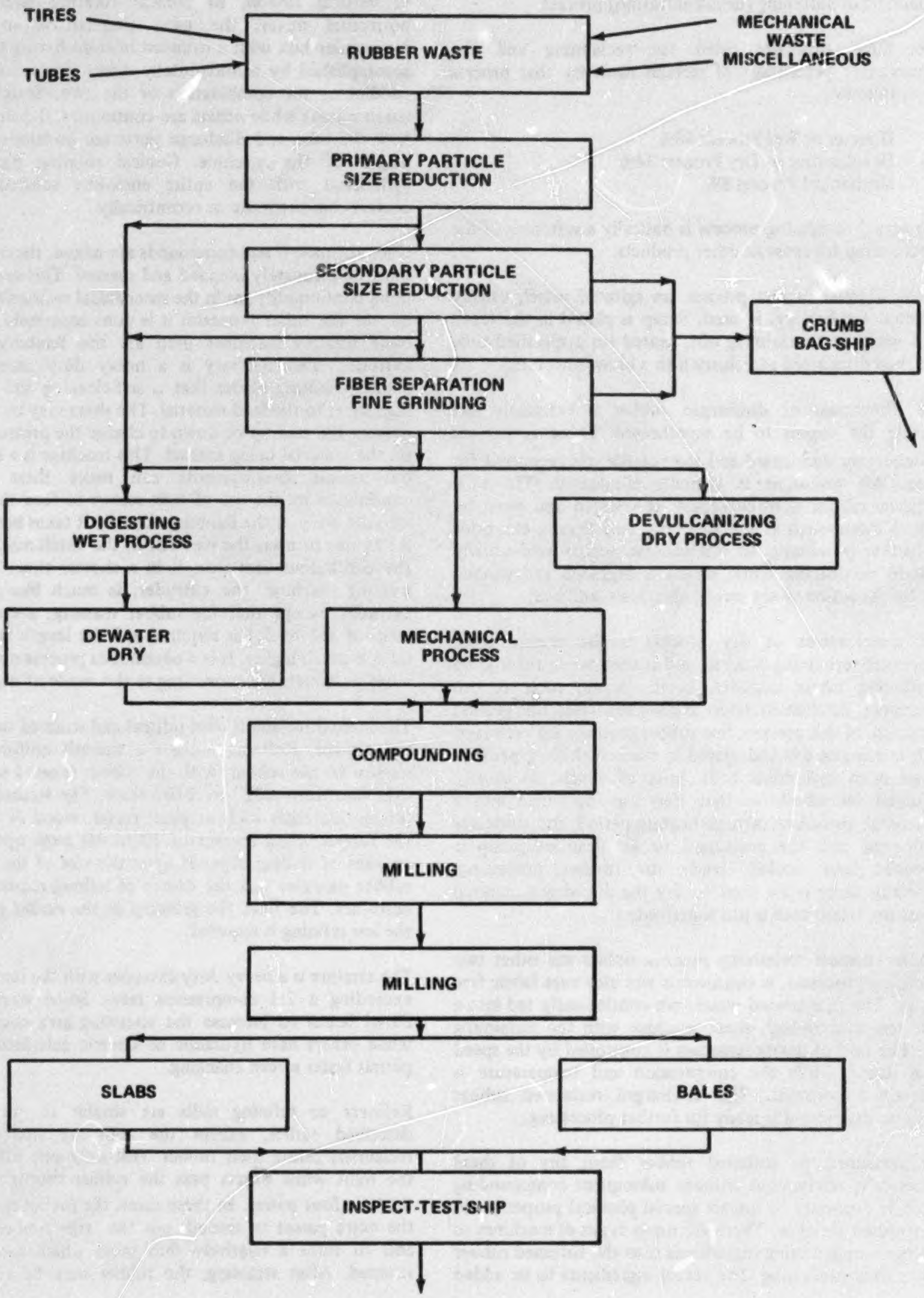
Once the size reduction process is completed, the fiber containing wastes may require either the additional process of mechanical fiber separation or chemical degradation and washing out of the fiber in the wet process. This washing sequence creates an effluent problem. The mechanical separation sequence is used by most reclaimers to circumvent the water pollution problem inherent in the digester or wet process. The fiber separation and fine grinding process is, therefore, associated primarily with scraps which contain reinforcing fiber materials such as cotton, rayon, nylon, polyesters, fiber glass and metal. In order to efficiently size reduce the waste before the actual reclaim process, the scrap must be separated from the reinforcing materials immediately after the initial size.

The input stream to the fiber separation process is first separated into different particle sized streams by a screener with several screen decks. These streams are fed onto air separation tables which effectively separate loose fiber pieces from clean rubber pieces by vibration and air flotation. The entire band of rubber/rubber-fiber/fiber is broken up into separate streams where the clean rubber is removed from the system. The fiber and rubber-fiber pieces are then fed into hammer mills for a hammering or scraping action. The degree of scrapping and size reduction is governed by the peripheral screen or perforated plate. After the material has been hammered or scraped sufficiently to pass through the screen, it is then fed to sifters or beaters. These machines, by a gentle beating, permit loose particles of rubber to be separated from the fiber and pass through a retaining screen while the fiber is conveyed to the end of the beater. The separated rubber is sometimes considered clean and is removed or if not clean enough, it is recycled to the screeners. As to the fiber, it is recycled either to the screener or to another set of hammer mills.

The last phase of the fiber separation process is baling the waste fiber that is removed from the scrap. This baled fiber is usually made up of small strands, less than 1½" long, and contains a very small amount of entrapped rubber. If there is a market for this fiber, it is reused, otherwise it is discarded. In some instances, the fiber is further processed by passing it through a carding machine to further cleanse the fiber for reuse.

The fiber separated rubber is conveyed to a storage bin for further size reduction. This size reduction is in the form of fine grinding. Crackers, much like those used in primary size reduction, with very small axial corrugations permit size reduction of the rubber to -30 mesh or smaller. Hammer mills as described earlier can also be used for the finer grinding of the rubber but are not as efficient as crackers.

FIGURE II-7 RECLAIMING PROCESS CHART


TIRES
TUBES
RUBBER WASTE
MECHANICAL WASTE MISCELLANEOUS
PRIMARY PARTICLE SIZE REDUCTION
SECONDARY PARTICLE SIZE REDUCTION
CRUMB BAG-SHIP
FIBER SEPARATION FINE GRINDING
DIGESTING WET PROCESS
DEVULCANIZING DRY PROCESS
DEWATER DRY
MECHANICAL PROCESS
COMPOUNDING
MILLING
MILLING
SLABS
BALES
INSPECT-TEST-SHIP

Material that has gone through the crackers or hammer mills is then screened. Particles that pass through the screens are considered product while the remaining material is recycled for further size reduction. This clean and fine ground rubber crumb is now ready for the heat of the reclaiming or softening (devulcanization) process.

The three processes used for reclaiming and the approximate percentage of reclaim made by that process are as follows:

Digester or Wet Process 58%
Devulcanizer or Dry Process 34%
Mechanical Process 8%

The actual reclaiming process is basically a softening of the rubber scrap for reuse in other products.

In the digester or wet process, an agitated vessel, usually jacketed for heating, is used. Scrap is placed in the vessel with water and reclaiming oils, heated for a specified time and then discharged as a slurry into a blowdown tank.

The blowdown or discharged rubber is extremely hot causing the vapors to be superheated. These vapors are subsequently condensed and the volatile oils recovered for reuse. Air pollution is virtually eliminated. The now softened rubber is mechanically de-watered and dried by various means such as hot air ovens, tray dryers, etc. prior to further processing. In this process, scraps used usually contain reinforcing fabric which is degraded and washed out by the action of the water, chemicals, and heat.

The devulcanizer or dry process is the second most important reclaiming process, and is used when there is no reinforcing fibers included in the scrap, such as tire innertubes, mechanical scrap or fiber separated fine ground tire scrap. In this process, fine rubber particles are premixed with reclaiming oils and placed in stacked shallow pans, or in an open cylindrical boat, both of which are usually mounted on wheels so that they can be rolled into a horizontal autoclave. After a heating period, the autoclave is opened and the reclaimed or devulcanized scrap is unloaded and cooled, ready for further processing. Generally there is no need to dry the discharged material unless the steam used is not superheated.

The mechanical reclaiming process, unlike the other two preceding processes, is continuous and also uses fabric free wastes. The fine ground wastes are continuously fed into a high temperature-high shear machine with the reclaiming oils. The rate of devulcanization is controlled by the speed of a screw, while the compression and temperature is maintained constant. The discharged reclaimed rubber needs no drying and is ready for further processing.

The reclaimed or softened rubber from any of these processes is rarely used without subsequent compounding which is necessary to impart special physical properties to the finished reclaims. There are many types of machines to mix the compounding ingredients into the softened rubber before final processing. The actual ingredients to be added are in the form of low and high viscosity, heated and unheated liquids; granular and powdered fillers, pellets, etc. These ingredients must be thoroughly dispersed into the softened rubber. The mixers most commonly used to incorporate the fillers into the rubber are either horizontal or vertical ribbon, or conical rotating blenders. The horizontal mixer, the most popular, is an enclosed rectangular box with a rounded bottom having the mixing accomplished by a horizontally driven continuous ribbon, paddles or the combination of the two. Some units are batch mixers while others are continuous, depending upon how the inlet and discharge ports are positioned and the length of the machine. Conical rotating blenders are cylindrical with the entire enclosure rotated between centers concentrically or eccentrically.

Once the rubber and compounds are mixed, these materials, must be intimately blended and massed. This is sometimes done continuously, as in the mechanical reclaiming process, but in the other processes it is done separately. The two basic massing machines used are the Banbury and the extruder. The Banbury is a heavy duty machine with counter-rotating blades that is self-cleaning and imparts a high shear to the feed material. The shear may be altered by moving the ram up or down to change the pressure exerted on the material being massed. This machine is a batch type but recent developments can make these machines continuous by the use of twin screws to feed the material into the body of the Banbury. Usually it takes between 1 to 3 minutes to mass the material in the batch machine while the continuous unit does it in a shorter time. The other massing machine, the extruder, is much like any other extruder except that for rubber massing, a compression ratio of 3:1 to 5:1 is required and the length to diameter ratio is much higher. It is a continuous process machine and more reclaimers are converting to this mode of massing.

The massed reclaim is then refined and strained to complete the process. Refining imparts a smooth uniformly clean quality to the rubber, with the rubber sheeted into a very thin film from .002" to .010" thick. The strainer removes foreign materials such as glass, metal, wood or sand from the rubber, using screens of 10 to 40 mesh opening. The amount of milling depends upon the size of the reclaimed rubber particles and the degree of milling required by the customer. The finer the grinding in the earlier processing, the less refining is required.

The strainer is a heavy duty extruder with the screw seldom exceeding a 2:1 compression ratio. Some strainers have flared heads to increase the screening area and capacity, while others have hydraulic or electric activated heads to permit faster screen changing.

Refiners or refining mills are similar to the crackers described earlier, except the rolls are smooth. Some reclaimers refine their rubber with only one pass through the mills while others pass the rubber through mills for three or four passes. In these cases, the rubber is milled for the extra passes to smooth out the large rubber particles and to form a relatively thin sheet which can then be strained. After straining, the rubber may be given more passes in the mills to further squeeze the small rubber particles to form a very smooth homogeneous sheet.

The finishing operation may be combined with the refining and straining but for clarity it is separated in this report. Each reclaimer may complete his reclaiming operations in either of two ways – by sending his product to the customer in the form of slabs, stacked on pallets, or in bales. Slabbed reclaim is made on a mill and the discharged sheet is wrapped on a rotating drum of a specified diameter, until the proper thickness is required. The wrapped layers or sheets are then cut off the drums, forming a solid slab of a certain length, width, and weight. The slabs are then dusted to prevent sticking to each other, tested and shipped to the customer. Baled reclaim, is similar in the milling sequence, except the thin milled sheet is conveyed to a baler, where the rubber is compacted to form a bale. The bale is then encased in a bag, stacked on a pallet and sent to customer after testing.

Another reclaim process not discussed in detail is crumbed rubber waste (Figure II). This material is any type of non-reinforced rubber, not softened like regular reclaim, but finely ground in cracker mills to a very discrete particle size, bagged and sent to the customer.

TRENDS IN THE RECLAIM INDUSTRY

Despite the steadily increasing production and use of rubber products in the United States, the trend is downward for recycle or reuse of waste products as reclaim. As a percent of new rubbers produced, reclaim has declined from 19% in 1958 to 10% in 1968. (Figure II-8) Some of this reduction is probably due to development of new rubbers not compatible with present reclaims. Undoubtedly, the major reductions were caused by cost, quality, or esthetic reasons. A comparison of the reclaim usage in 1960 with 1967–'69 (TABLE II-8) indicates substantial reductions in some usages by application. Competitive materials as rugs, colored plastics have reduced usage in automotive mats and mechanical parts from 105 million pounds in 1960 to approximately 55 million pounds. Similar reductions are noted for other mechanical goods, hose, shoe heels and soles, and hard rubber products. In general the tire and innertube application consumption has remained virtually constant at the 380 million pound level.

Whole tire and butyl reclaimed rubbers are incorporated in innerliner compounds to reduce cost, improve processing and improve air retention (butyl reclaim).

Improved compounds and constructions which minimize the liner requirements have resulted in some reduction in liner compound and also the reclaim. Increased flexing and heat buildup caused by lower tire pressures, low aspect ratios, and higher speeds have resulted in a trend towards the substitution of new rubber for the reclaimed rubber in the innerliner.

FIGURE II-8 RECLAIM CONSUMPTION AS A PERCENT OF TOTAL NEW RUBBER

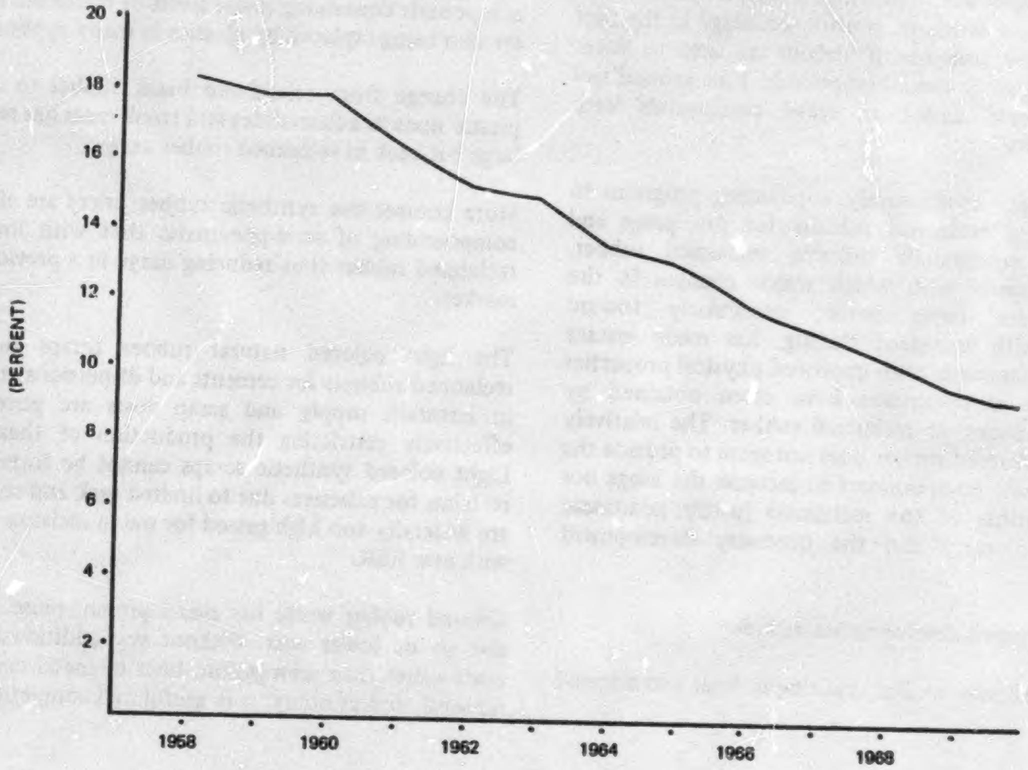


TABLE II-8

RECLAIM CONSUMPTION BY PRODUCT

	'60	'67	'68	'69*
Tire & Tire Repair Mat'l	380.6	364.3	385.3	377.4
Innertubes		15.2	30.0	18.6
Auto Mat & Mech	104.8	55.8	57.6	55.3
Hose, Belt	36.1	26.2	24.9	31.8
Mechanical Goods	52.6	31.8	23.5	32.9
Non Automotive				
Cements & Dispersions	15.7	16.4	18.4	19.7
Heels, Soles	17.0	8.7	11.4	5.6
Hard Rubber	26.2	14.3	7.4	6.7
Rubber Surface	–	4.9	5.1	3.3
All Other	22.9	11.0	12.1	8.3
Total	655.9	548.6	575.7	559.6

*RRA Estimate

Despite the usual cost reduction and improved processing advantages to tire carcass production, the increased heat buildup reported for these compounds containing reclaimed rubber has resulted in some reduced usage in carcass compounds. Sidewall compounds which have traditionally contained large amounts of reclaimed rubber to control shrinkage of the extruded sidewall, eliminate mold blemish and lower costs, are also undergoing a trend towards reduced usage. This again is due to the requirement for compounds with increased resistance to the flex cracking brought about by the increased flexing in lower pressure tires, wide oval types, and the increased ozone concentrations in the atmosphere. The low abrasion resistance of compounds containing reclaimed rubber limits its use to very low levels to control shrinkage in the first line treads. Larger amounts of reclaim are used to lower costs of lower quality tread compounds. Fine ground tire peelings are being added to tread compounds with satisfactory results.

The reclaimers are continuously conducting programs to develop improved reclaimed rubbers for tire usage and improved tire compounds utilizing reclaimed rubber. However, the speed with which major changes in tire constructions are being made, particularly toward constructions with increased flexing, has made instant demands for compounds with improved physical properties which the tire compounders have often obtained by reducing the amount of reclaimed rubber. The relatively low price of reclaimed rubber does not seem to provide the incentive for these compounders to increase the usage nor do the low profits of the reclaimers justify additional expenditures to carry out the necessary development program.

Some of the required developments include:

1. Improve resistance to flex cracking in liner and sidewall compounds.
2. Improve low and high temperature liner compounds.
3. Study of reclaim in carcass compounds.
4. All of the above will require both laboratory work and extensive service tire testing.
5. Lower cost reclaim rubber.

A number of other products which have traditionally used large quantities of reclaim are also using less reclaim at the present time.

Hard core soft tread tires are being molded from compounds containing lower levels of reclaimed rubber and are also being replaced by plastics in many applications.

The change from calendered black rubber to carpet and plastic mats in automobiles and trunk mats has resulted in a large cut-back in reclaimed rubber usage.

More competitive synthetic rubber prices are allowing the compounding of semi-pneumatic tires with low levels of reclaimed rubber thus reducing usage in a previously major market.

The light colored natural rubber scraps required for reclaimed rubbers for cements and dispersions are no longer in constant supply and scrap costs are generally high, effectively restricting the production of these reclaims. Light colored synthetic scraps cannot be formulated into reclaims for adhesives due to limited tack and solubility and are generally too high priced for use in reclaims to compete with new SBR.

Ground rubber waste has many present reuse applications due to its lower cost. Without any additional reclaiming costs other than segregation, fiber or metal contamination removal, and grinding, it is useful and competitive to other materials for molded rubber applications. The lower transportation cost advantages of bulk shipments of this crumb rubber cannot easily be achieved due to the ICC regulation classifying this material with a yellow label as inflammable.

Reclaimed rubber formerly used in hard rubber products, battery cases, combs, etc. has been almost completely replaced by new rubbers and plastics due to the lower and product cost possible with these materials.

In general it can be seen that the low SBR prices are allowing compounding in competition with reclaimed rubber and until there is a definite economic advantage for reclaimed rubber no trend toward increased usage can be anticipated.

PROCESSING ADVANTAGES AND COST SAVINGS

The use of reclaimed rubber whether as a source of rubber hydrocarbon or as a compounding ingredient will usually result in compounds with lower overall costs and improved processing characteristics.

Traditionally one of the main advantages of reclaimed rubber has been the competitive lower cost. This is no longer true with respect to material cost due to the low priced, oil extended synthetic rubbers. Even with this fact established, the stable low price of reclaimed rubber offers an advantage in helping stabilize new rubber prices and providing a firm base for estimating cost.

The chemical action of the reclaiming process combined with the extensive mechanical refining and the presence of fillers results in a product with low nerve. This low nerve is responsible for many of the processing advantages gained from the use of reclaimed rubber. Reclaimed rubber compounds generally process faster in extrusion and calender operations with significant reduction in shrinkage and die swell and improvement in gauge control. Heavy gauges can be calendered blister-free at high rates when reclaimed rubber is added. These compounds also exhibit less heat build up during processing and will cure uniformly in fast higher temperature cycles.

Reclaimed rubber's low nerve can reportedly reduce the fabricator's power costs as much as 35%. The peak horsepower demand, which usually determines the electrical cost rate, is also significantly reduced, increasing the savings. It has been estimated from experience that a reduction of one minute per batch in mixing time by the use of reclaim in standard compounds reduces costs by as much as four dollars per ton of compound and permits an increase in thruput rates of up to ten percent.

Other dollar savings are realized from the faster processing of extruded and calendered stocks; less rework due to out-of-specification processed parts; short and safe high temperature cure cycles; and fewer defective finished parts.

Following is a list of technological and marketing advances which reclaimers recommend as ways to improve the consumption of their products:

a) The establishment of standard specifications for reclaims to be established by the Rubber Reclaimers Association. Reclaimers will produce these at their discretion for general market consumption in addition to their regular customer-oriented reclaims.

b) The improvement of abrasion resistance: Although the reclaimers mills do a very thorough job of mixing reclaim components, high magnification inspection reveals "pockets" of carbon black, fillers, oils, etc. These pockets readily abrade and a more thorough method for dispersion must be sought.

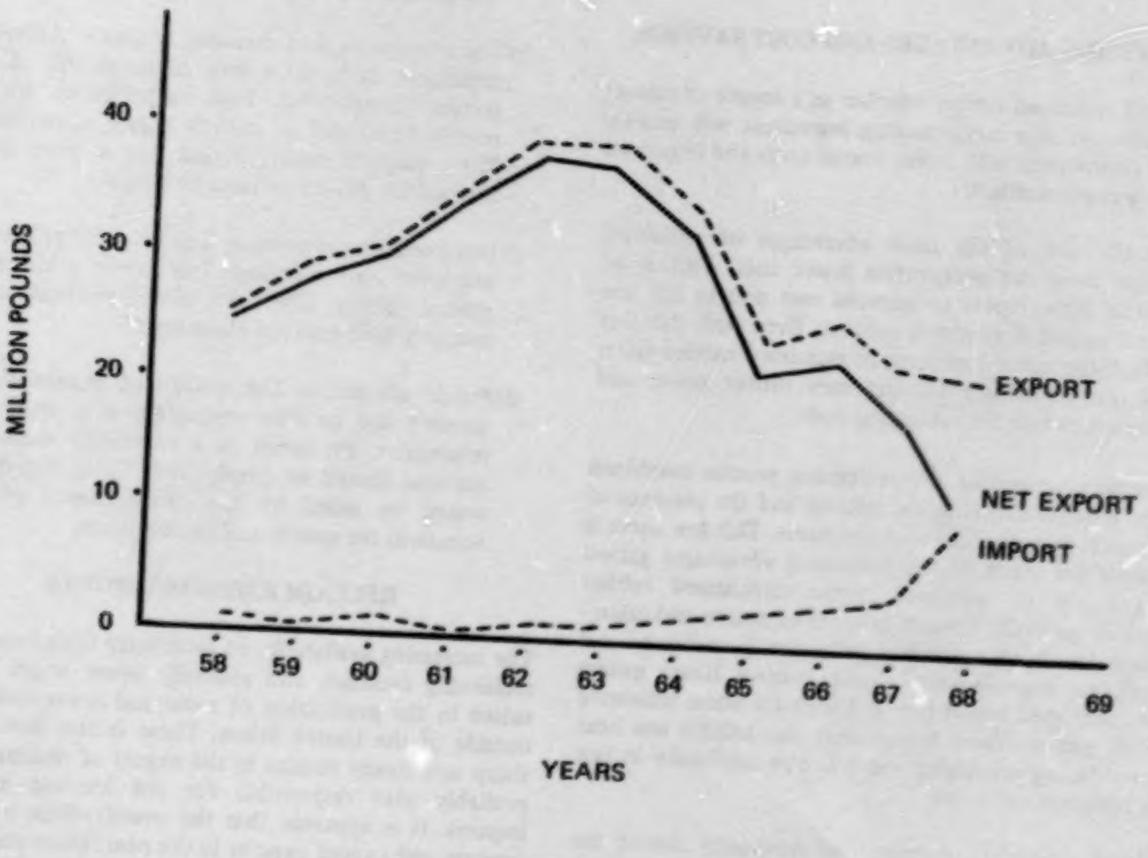
c) Improved heat resistance. The need for products with improved heat resistance has forced a change from natural rubber, SBR and related reclaims to newer specialty heat resistant elastomers.

d) Public education: The quality of reclaim should be stressed and its false reputation as a cheap diluent minimized. An image as a technically desirable raw material should be emphasized. These two objectives would be aided by the establishment of reclaim standards for quality and performance.

RECLAIM EXPORTS/IMPORTS

The increasing availability of local scrap tires, expansion of reclaiming facilities, and generally lower wages have resulted in the production of more and lower cost reclaims outside of the United States. These factors have caused a sharp and steady decline in the export of reclaims and are probably also responsible for the increase in reclaim imports. It is apparent that the overall effect will be that imports will exceed exports in the near future and that this change will be reflected as a reduction in domestic reclaim production. (FIGURE II-9)

FIGURE II-9 RECLAIM EXPORTS/IMPORTS



Section III
The Retread Industry

TIRE RETREADING HISTORY

Tire retreading had its beginning over 60 years ago. The first retreads were produced by cutting off the remaining old tread, buffing the surface and applying a layer of vulcanizable cement on the tire. Then a tread which had been previously vulcanized was buffed, cemented and placed around the tire. A flexible steel coil was placed inside the tire and the assembly was wrapped with canvas strips like a bandage. The tire was then placed in a kettle or tub and vulcanized with live steam. In 1912 "Dry Tread Cures" were introduced. Here, an unvulcanized tread was placed on the buffed tires. The tires were then placed in a quarter circle mold where a portion of the tread was cured. After one section was cured the tire was turned in the mold and the cure continued until all sections of the tread were vulcanized. Heat was supplied by coal or gasoline fired boilers. The pressure necessary to vulcanize the rubber to the tire was applied by clamps and sand bags placed inside the tire. In the early 1920's the first full circle retread mold appeared and retreading began to progress. By 1926 a mold in the shape of a circular heater was introduced that, fitted with various aluminum forms, could retread several sizes of tires. This was developed into a clam shell type of mold with boilers operated by a small gas or oil burner.

THE RETREAD INDUSTRY

A retreader converts worn tires by applying new tread compound in such a manner as to make the tire reusable. Depending on the number of times the individual tires are retreaded, the useful life of the original tire is substantially extended.

In the years 1930 to 1940 passenger tire retreading grew at a rate of 10% per year. By 1944 – when World War II production was at its height – retreads accounted for 30 million units. Following a large drop in production after the war, the retreading industry has since grown at a rate of approximately 3% per year.

The estimated number of passenger car tires retreaded increased from 29.9 million units in 1958 to approximately 36 million units in 1963 and has remained fairly constant since that time. The larger sized truck tires retreaded has increased steadily from 7.3 million retreads in 1958 to 9.7 million in 1968 (TABLE II-9).

A comparison of retread versus new tire production indicates retread passenger tires constitute approximately 17% of tires in use. Retread truck tires constitute 28% of tires in use. Without the retread industry, all tires now retreaded would have been added to solid wastes in the year retreaded and new tire production would have been increased to replace them, adding still further to the solid waste disposal problem.

TABLE II-9

PRODUCTION OF RETREADED TIRES
(Millions of Tires)

	Passenger Car Tires	Truck
1958	29.9	7.3
1959	32.4	7.6
1960	30.6	7.4
1961	31.9	7.6
1962	34.5	7.7
1963	36.3	7.5
1964	36.0	8.0
1965	36.0	7.6
1966	35.3	8.0
1967	34.5	9.3
1968	35.8	9.7
1969*	36.5	10.0

*Estimated

There are approximately 8,500 retread plants in the United States of which 8,000 are independent dealers and retreaders. The balance are operated by large tire companies and other mass marketing organization or chains.

The estimated daily capacity is 211,650 units, equivalent on an annual basis to 50-60 million units depending upon the number of days operated. Capacity utilization is then calculated to be approximately 85%.

Usage of Rubber Waste

A majority of retreaders receive their tires from scrap dealers. The next largest source for retreaders is turn-ins, tires left at the store when replaced by new ones. Steel reinforced tires are presently being retreaded, however studded tires are done only on request from specific customers.

Tires actually successfully retreaded and put back into service accounted for 1.242 billion pounds recycled in 1958 and 1.560 billion pounds for 1968. (TABLE II-10). This usage does not include any units rejected as being unsuitable prior to retreading or the estimated 3% rejected after retreading. Usage is calculated by multiplying the number of reported retreaded tires by 23 pounds for passenger tires and 76 pounds for truck tires. This is the average original weight minus 8% and 8½% tread loss respectively.

TABLE II-10

WEIGHT OF WORN TIRES USED IN RETREAD INDUSTRY

THOUSAND OF POUNDS*

	Passenger tires	Truck tires	Total
1958	687,700	554,800	1,242,500
1959	745,200	577,600	1,322,800
1960	703,800	562,400	1,266,200
1961	733,700	577,600	1,311,300
1962	793,500	585,200	1,378,700
1963	834,900	570,000	1,404,900
1964	828,000	608,000	1,436,000
1965	828,000	577,600	1,405,600
1966	811,900	608,000	1,419,900
1967	793,500	706,800	1,500,300
1968	825,400	737,200	1,560,600
1969	(839,500)	(760,000)	(1,599,500)

(Estimated)

*The tread rubber added to the casings is included in the 10.7 billion pounds of new rubber products manufactured in 1968.

Very little solid waste is created by the retread industry. The largest waste item is tread buffings generated during the preparation of the tread surface prior to application of the new tread. The old surface is buffed with wire brush wheels hence the term "buffings" for the abraded rubber dust. Approximately 1½ pounds and 4 pounds of buffings are produced from passenger and truck tires respectively. Calculated buffing weights based on tires processed indicates a waste increase from 74 million pounds in 1958 to 92 million pounds for 1968, or approximately 6% of the weight of the waste tires recycled (TABLE II-11).

TABLE II-11

BUFFINGS PRODUCED ANNUALLY

Millions of Pounds

	Passenger	Truck and Bus	Total
1958	44.9	29.1	74.0
1959	48.7	30.5	79.1
1960	45.9	29.7	75.7
1961	47.8	30.3	78.1
1962	51.7	30.9	82.6
1963	54.4	29.9	84.3
1964	54.0	31.9	85.8
1965	54.0	30.2	84.2
1966	52.9	32.7	85.1
1967	51.7	37.1	88.8
1968	53.7	38.8	92.5
1969	*54.8	*40.0	94.8

*Estimated

In 1968 reclaimers reported using 97,378 pounds of these buffings equivalent to less than 1% of years total. It is known however, that substantial quantities of this material are used in other industries i.e. brake lining, asphalt composition, etc. No reported data is available.

Rejected retreaded tires amount to about 3% of those retreaded. This is equivalent to 550,000 pounds of waste per year consisting of approximately 90% old waste tires plus 10% of new tread rubber added to tire.

Less than 5% of total industry waste has been reported as being from packaging materials. This is equivalent to approximately 4 million pounds per year.

Total industry waste in 1968 was 99.3 million pounds of which 95 million pounds was unused tire waste (TABLE II-12).

TABLE II-12

Total Waste From Retreading Industry – 1968

Thousand of Pounds

From Waste Tires	weights
Buffings	94,750
Rejected Retreads	550
Subtotal	95,300
New Waste	
Packaging	4,000
GRAND TOTAL	99,300

PROCESSES

The retreading of a tire today involves several steps. First the old tire is inspected. Without a sound casing or tire carcass all other production efforts and controls are of no value. There must be no cuts or deterioration of the reinforcing fabrics. Air is injected into the shoulders of the tire to detect hidden ply separations, the major cause of tire failure. The tire is now vented in the bead area. This will allow trapped air to escape during the molding process or during highway flexing. Any trapped air could expand to cause ply separation. The tire is now buffed. All the remaining tread is ground off in this step. After buffing, the crown is cleaned with a stiff wire brush to remove any rubber dust. The next step is to measure the tire. Tires have a tendency to "grow" after some road use. This growth can amount to 7% of the tires original width. After this measurement, the wall thickness of the tire is determined. This is necessary in order to select the correct curing rim and assure a tight fit of the tire in the matrix. Vulcanizable rubber cement is now sprayed on the tire. Strips of tread rubber are wound circumferentially around the tire. This tread rubber called "fast cure", was introduced in 1957 and cuts the vulcanization time 20%. From here the tire goes into the mold where is is cured. Later it is inspected and made ready for delivery. One third of the retreaders today "program" the tread on. In this method, a thin strand of tread stock is slowly wound around the tire. The machine operator selects the profile he wants built onto the tire and the machine automatically wraps the rubber strand around until the exact contour is built up. The curing and inspection steps follow.

The next major process in use is called the "Bandag". It is used primarily on truck and bus and larger tires. The tire is prepared as usual and a partially cured tread is placed on the tire. The tire is now cured in a much shorter time. The shorter cure helps to extend the life of the tire as heat deteriorates the tire rubber, and also weakens the fabric. A shorter cure time has another advantage in that it helps to achieve better production rates from expensive curing apparatus.

TRENDS IN THE INDUSTRY

There are many factors that are limiting the retread industry growth and hence the reuse of road worn tires. (1) It was noted that passenger tires retreaded have plateaued out at approximately 36 million units from the period 1963 to the present. The main growth in units recycled has been in the larger size, truck tires. However, in terms of percent of new tires recycled, passenger tires have dropped from 25% in 1963 to 17% in 1968. Truck tire recycle has also dropped from 32% to 28% (FIGURES II-10 and II-11). There are many reasons for this lower reuse of waste tires. In general, the average passenger tire customer views retreads as a "second class citizen" of the tire world. This connotation evidently arises from the idea that "used" materials are always inferior to new materials regardless of the quality of the new materials. With respect to tires, it may also be related to some poor customer experience as far back as the customer may remember, possibly to the post World War II period before the industry reached its present level of sophistication. The growth of units recycled in truck and airplane type tires however tends to negate this type of thinking. Users of these tires are looking for service and cost and are not hesitant to retread tire casings more than one time if possible.

The apparent reluctance to accept retreaded passenger tires as readily as truck type tires are accepted may be valid by reason of quality differences. It has been noted that these larger tires require larger equipment and hence may only be handled by larger retreaders, those who may have more sophistication than some of the smaller shops. Also the shortage of suitable passenger tires available for retreading may lead to relaxation of standards.

Retreaders in general try to retread only the best grade of tires, eliminating the lower cost, lower quality, lines of new tires. Testing of the better grades also eliminates many tires as unsuitable for retreading due to damaged carcasses, etc. The approximate 20% level of retreaded tires from all new tires manufactured leads one to believe that this level may not be easily exceeded, because of excessive carcass abuse in normal service. Retreading can only replace tread wear and cannot correct other damage.

Most competition comes from 3rd and 4th line new tires specifically designed to compete in the "retread" cost market. These tires, carrying the name brand of a national company are backed by national advertising and distribution. The small retreader competes against these with a brand-less tire. There is some "name" retread competition by national tire companies, selling retreads on their own brand carcasses.

A more complete review of the myriad of problems is available in the literature(1). The major problems are inherent in the complexity of tire sizes, tread widths, etc., and the variable expansion of the tire carcass during its original use. This forces the good retreader to measure each tire, maintain a large inventory of molds, juggle his inventory to maintain balance of salable sizes etc. Any future tire quality specifications may also complicate the retread industry.

All of these factors have tended to increase the cost of retreading whereas the selling price has not increased proportionally thereby putting the squeeze on the industry profits. There is some feeling in the industry that this profit squeeze may have led in some instances to lowering of quality. If there is any basis in this viewpoint, it can only lead to reinforcing the "second class" status of the entire industry.

Some representatives of the industry believe that reasonable, workable standards for the industry could lead to increased usage of retreads by improved quality, and better acceptance by the public through improved reliability. Unworkable standards may conversely seriously restrict the largest single converter of tire waste.

(1)Braner, H.H., An Analyses of the Domestic Retreading Industry, Ranno Printing Co., Englewood, N.J., 1965

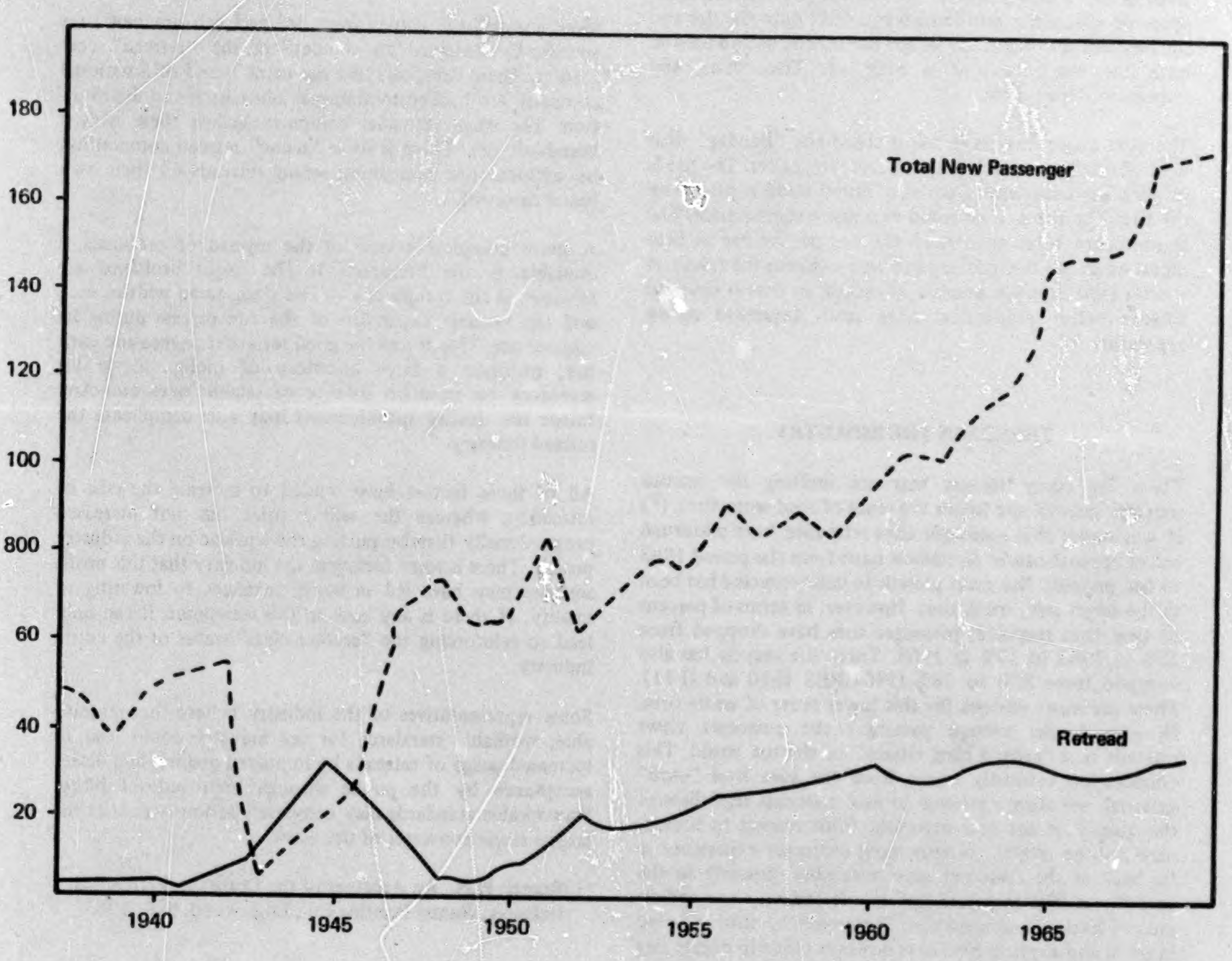


FIGURE II-10 DOMESTIC PASSENGER TIRE SHIPMENTS AND RETREADS (MILLION UNITS)

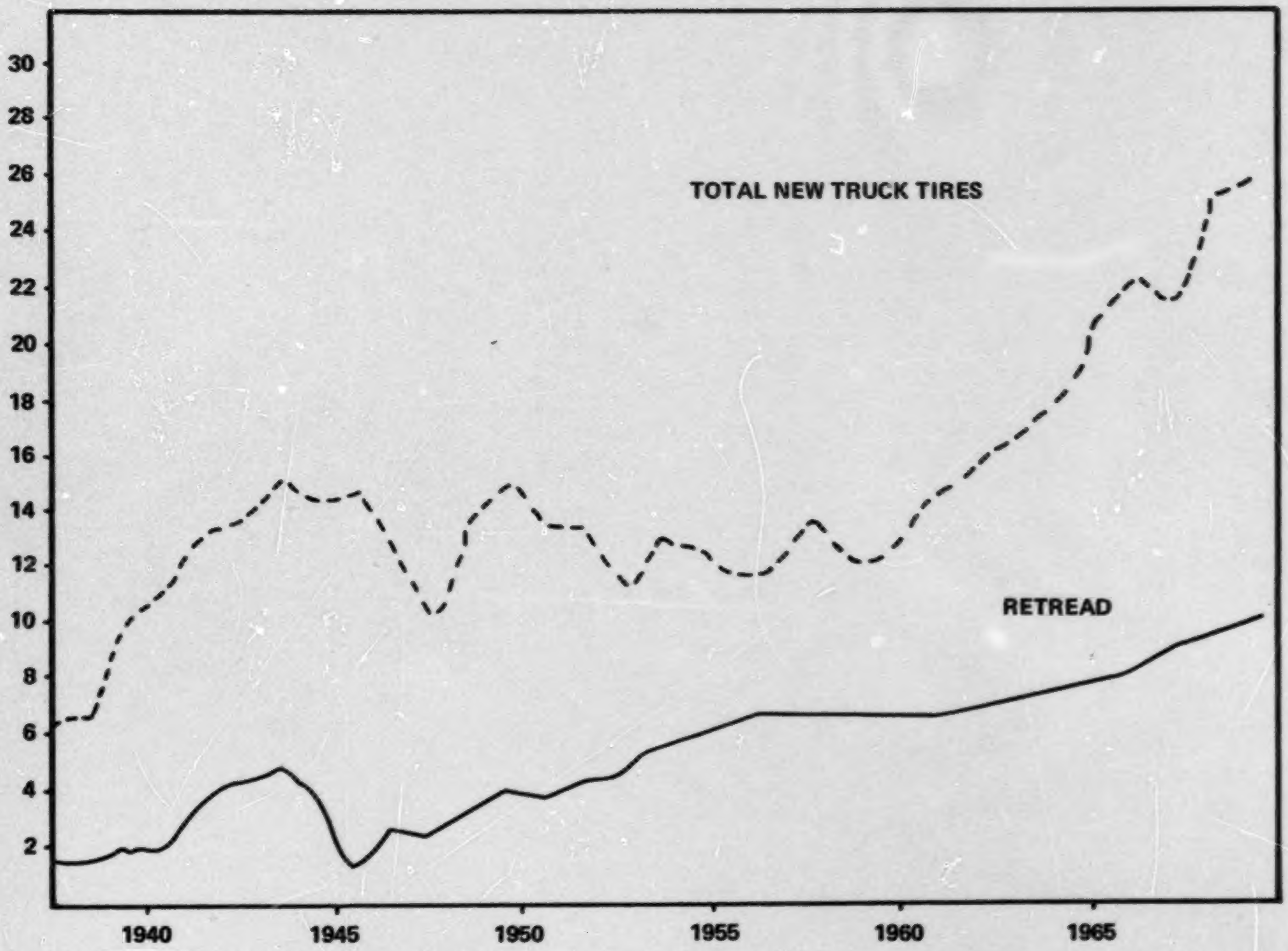


FIGURE II-11 DOMESTIC TRUCK TIRE SHIPMENTS AND RETREADS
(MILLION UNITS)

Section IV

The Tire Splitting Industry

HISTORY OF TIRE SPLITTER INDUSTRY

Around 1915 when tires became available in large quantities, the forerunners of tire splitters called tire pullers came into being. The industry consisted of pulling the cotton fabric off old tires, thus separating certain plies of fabric from each other and from the tread and sidewall. The bead was first removed to make the carcass flexible. Bead removal was first done by hand and later by machine.

John Ball discusses the operation in his book "Reclaimed Rubber, The Story of An American Raw Material." R.R.A. New York 1947. "The pulling of tires was first done by hand, then with a pulley attachment, and later by a simple motor driven machine. The elementary methods were quite satisfactory as long as the fabric used in tires was square woven duck, which has good strength and cohesion in any direction to withstand the sudden pull or jerk." The introduction of Weftless Cord in tires instead of square woven duck made it very difficult to separate plies and tire splitting instead of tire pulling came into being around 1925 when machines used to split hides and leather in tanneries were employed to split tires. During the war years, the prices of blowout patches and reliners, both typical products of tire splitters became very high. As a result, tire splitting became a very big business and in the summer of 1945 over 125 splitters were in operation. They accounted for about 1/3 of all the tire scrap received by the reclaimers.

TIRE SPLITTER INDUSTRY

A portion of the nation's waste rubber is consumed by the tire splitting industry. These little known companies use worn-out bus, truck, and passenger tires. The bead wire is removed by cutting or stamping; the tread is cut and peeled off the tire carcass and the remaining carcass is slit into three sections, the crown or tread and the two sides. These carcass sections are now planed to uniform thickness and placed in a press which die cuts out the final product. Typical products are gaskets, shims, automotive tail pipe insulators, and the familiar door mats. Circular and square pieces are also stamped out and bolted or pinned together to form items such as conveyor rollers for handling produce, light load V-belts, and bumpers for docks and loading platforms. Today there are three tire splitters in business (Note 1.) Each, however, has an optimistic view of his market and production and sales increases of 10 to 30% are expected.

A total of 239 people are employed in the tire splitting industry, 29 of which are salary and 210 are wage. All of these companies are located within communities of 100,000 population or more. During the year 1968, splitters consumed 39 million pounds of passenger tires and 15 million pounds of truck and bus tires, are normally accumulated within a 100 to 200 miles radius from their production facilities. The cost, up to $15/ton-delivered, is somewhat higher than the average cost of scrap tires to conventional reclaimers.

Note 1

1. A. Lakin & Sons, Inc. Chicago
2. A. Schulman, Inc. E. St. Louis, Ill.
3. A. Baker Manufacturing Co. South Bend, Ind.

SOLID WASTE & BY PRODUCTS FROM INDUSTRY

Of the 57.5 million pounds of scrap tires consumed by the industry, 14 million pounds were converted into finished product (25%). The remainder was converted into 36 million pounds (63%) of useable by-product which was sold to reclaimers. The remaining 7 million pounds (12%) was returned solid waste. (TABLE II-13) In addition to the 7 million pounds of rubber waste not used, the industry created three and one-half million pounds of new waste. (TABLE II-14)

TABLE II-13
TIRE SPLITTERS-MATERIAL BALANCE (in 1000 pounds)

PRODUCTS	
Split Tire Products	13,980
By Products-To Reclaimers	
Tread peels (a)	8,200
Carcass Selvage (b)	27,892
	36,092
SOLID PROCESS WASTE	
Bead Wire (c)	4,480
Tires Unsuitable For Splitting (d)	2,980
GRAND TOTAL TIRES PROCESSED	57,532

(a) Tread portion of tires which is peeled off.

(b) Remainder of tire carcass after parts are die cut out.

(c) Bead wire portion of tires including rubber and fabric covering which is cut from tire. Also includes 660,000 pounds of process waste, selvage, which is lost as floor sweepings. This is disposed of with normal trash.

(d) Unused tires which are sorted from purchased scrap tires as not being worthy of splitting, mainly studded winter tires, steel re-inforced tires, and tires too small to process.

TABLE II-14

TIRE SPLITTING INDUSTRY WASTE
(in 1000 pounds)

SOLID PROCESS WASTE	**WEIGHT**
Unuseable Tires	2,980
Bead Wire & Bead Rubber	3,820
Process waste, selvage, sweeping	660
Sub-total	7,460
OTHER SOLID WASTE	
Packaging Materials	1,660
Other Categories	1,920
Sub-total	3,580
Grand Total	11,040

The overall industry material balance then becomes

57,532,000 lbs. scrap tires accumulated
13,980,000 lbs. of parts produced and sold
36,092,000 lbs. of by-products sold mainly to reclaimers
7,460,000 lbs. of scrap tire waste dumped
3,580,000 lbs. of new waste dumped

The overall reduction in total waste accomplished by the industry is 46,492,000 lbs. By-products sold to the reclaimers, however, may create additional waste to those industries, particularly in the testile portion of carcass selvage. The 11 million pounds of industry waste are disposed of in sanitary land fills at a cost of 0.4 to 0.9 cents per pound. One company uses its own trucks and labor for dumping.

Section V
Mitigation

SOLID WASTE RUBBER MANAGEMENT PROGRAM

The data of this report suggests the possibility of classifying the entire waste rubber program into 3 broad areas:

a. Waste from the Rubber Industry
b. Automotive Rubber Waste
c. Consumer Rubber Waste

The Rubber Industry, as in any cost conscious industry, makes every effort to effectively reduce cost through reduction in waste product and re-use where possible. Some types of waste are kept segregated and sold to other processors for reuse such as the reclaimers. The second classification, that of Automotive Waste Rubber, is more easily segregated and accumulated after use than Consumer Waste. In addition a system already exists for the collection and utilization of this type. Consumer Rubber Waste is undoubtedly the most difficult to categorize due to the multiplicity of products and non-existence of segregation and collection facilities. While many of these consumer rubber products are reused in the reclaim industry when available as rubber industry waste, it is apparent that mixtures of these products are not easily nor economically reclaimed in any conventional manner. Any re-use of this vast mixture will undoubtedly be based on new techniques for new products. It is then recommended that the latter 2 divisions be reviewed with regard to:

a) Collection
b) Shipping
c) Storage
d) Potential Reuse
e) Ultimate Disposal

COLLECTION

The present method of collecting automotive rubber waste, predominantly tires, as outlined in Section I, could serve as a nucleus for further expansion. The method which accounts for approximately 30% collection of old tires for use in the 3 major reuse industries, should not require considerable revision to account for higher collection percentages. Scrap merchants presently gear their collection to reuse industry demand with the demand being filled from nearby areas to minimize shipping costs. Since collection is the reverse logistics of rubber products distribution, a procedure developed to minimize costs, a detailed study of this distribution may lead to more economical collection methods. It has been suggested that convenient and suitable collection sites would be automotive service stations and tire sales stores.

Other suggested collection sites are municipal disposal areas and unused armed forces areas.

Rubber waste such as tires, innertubes, and auto mats would account for approximately 68% of the rubber goods produced annually. To be accumulated automatically at these points, an economic incentive for this type of collection would have to be created by either new uses for these wastes which would cover the collection costs or an incentive to the consumer which would insure his turning the waste in, such as a deposit paid on the new article refundable upon turn-in. The latter does not appear practical as the collection sites could be overwhelmed by these worn out articles and it does not provide an incentive to the site operator. On the contrary, it requires him to maintain a costly collection and storage area.

Another plan might be a statutory surcharge on the original commodity selling price to pay for later public collection and disposal costs. This should be studied very carefully as it not only creates an additional tax on the consumer but may also be misinterpreted as license for casual discarding of the article. No convenient method of collecting the remaining rubber waste has been suggested by this report and it is recommended this be a separate study. It is possible that the inclusion of this waste in municipal waste that is to be incinerated may be helpful to the incineration, providing a readily combustible material to overcome some of the less combustible wastes. This being particularly true when wet wastes are to be incinerated.

SHIPPING AND STORAGE

If automotive tires are considered indicative of rubber waste, considerable economies could result if they are crushed or chopped as locally as possible prior to shipment to use points. The average tire occupies 1.3 cubic feet of space but when chopped, only occupies 0.5 cubic feet. More weight may be shipped per vehicle load or stored in any storage area by a factor of approximately 2½ to 1.

The recommended waste chopping may be done in stationary choppers in high waste areas or on portable choppers, moved on schedule, to low waste areas which cannot justify permanent installations. It has been estimated that the cost of a portable chopper would be $100,000. (TABLE II-15)

TABLE II-15

ESTIMATED COST OF PORTABLE RUBBER WASTE CHOPPER

1.	Flatbed tractor trailer	$40,000
2.	Alligator shears	5,000
3.	Hammer mill – hogger	30,000
4.	Screener	5,000
5.	Fiber separator/magnets	15,000
6.	Miscellaneous items	5,000
	Total (1968 prices)	$100,000

Testing of this type portable chopper in both high and low waste areas could achieve significant results, with the chopped waste also being evaluated locally as land fill or incineration fuel (see Potential Uses). It should also be noted that the design of either the stationary or portable chopper may be such as to prove of value in shredding other types of waste such as glass, wood, paper etc. so as to facilitate disposal or reuse. This should be an area of additional investigation.

One serious drawback to public transportation of ground or chopped rubber waste is the Interstate Commerce Commission designation of this type material. This regulation* prohibits the bulk transportation of ground rubber waste under certain conditions. This may restrict shipments in bulk via public carriers, handling and packing costs.

*49 CFR 170:15
49 CFR 173:22
Para 73.201

POTENTIAL REUSE WITH REPROCESSING

The largest potential outlet for scrap rubber is rubberized asphalt roads. This is a matter for serious study and all possible assistance should be given to this program. The use of rubber in roads was thought of, patented and tried well over 130 years ago. However, it was not until the 1920's that a serious set of laydowns took place in England on the Dartford-Gravesend Road, London, and Lombard St., Birmingham. In these trials, rubber was added to a pitch coated concrete road and rubber blocks served as the road itself. In the U.S. in 1925, Goodyear tried laying a road using solid rubber blocks but it was far too expensive and very slippery when wet. In the 1930's in Europe and England, the many institutes, laboratories and local rubber interests investigated the use of natural rubber, which was at a very low price, and of nitrile rubber. Many roads were laid and the most notable was the Bussum road in Holland laid in 1936 using rubberized asphalt which lasted through World War II even under heavy war-time tank traffic. The road laid in New Cross, London, by Dussek lasted into the 1960's. Much of the work which has been done in the past has been less than definitive and much has been based on the addition of new rubber or rubber latices, which may be useful but irrelevant to the problem of solid waste disposal. Some success was achieved in the work done prior to 1950 but the whole approach was empirical; there being no thorough understanding of how the rubber acted in modifying the properties of bituminous mixtures. From about 1950 onwards research was intensified. Many full scale experimental rubberized road surfaces were laid and from these trials many specifications were published by 1964. The specifications basically are for topping a road bed including recommended temperature ranges, aggregate and bituminum (asphalt) proportions and method of blending the recipe. In the English and European writings mention is often made on the use of latex, vulcanized and unvulcanized rubbers. A survey of selected articles on use of rubber in asphalt, indicates a high degree of potential for rubber scrap. However, there is no indication that raw ground waste could be used to enhance the road properties. Some degree of solubility is required and is not obtainable unless the rubber molecular weight is substantially reduced with a combination of heat, time and chemicals. Some of the properties inherent in scrap may be desirable in rubber for asphalt since it has been compounded, vulcanized to higher molecular weight, and has some residual antioxidant. It is estimated that at a 5% usage of rubber in all new asphalt paving, the national demand would be equivalent to the current generation of scrap rubber as tires. Studies in this important potential usage, restricted to ground cured rubber or reclaimed rubber, should incorporate:

a. Feasibility studies on the incorporation of rubber material in asphalts and in hot or cold mix plants.

b. Determination of optimum levels of rubber addition.

c. Initiation of long term studies of the service improvement value, if any, of such additions to pavings in actual installations.

d. The logistics of supplying the waste in usable form where needed. Grinding of waste at regional or local disposal sites may be beneficial.

e. The extension of the use of cured scrap or reclaimed rubber in asphalt to public play grounds, tracks, courts, parking areas, and curbing or other barriers.

f. Determination of the degree and means of subsidization required to ensure use of waste rubber in paving asphalts, or, alternatively the proper form of mandatory federal or state action to accomplish this purpose.

To date, the testing of waste rubber in roads has been mainly done by dealers in the commodity. While liaison has been established, between interested parties, a strictly organized program should be created and explored. Although a blanket endorsement cannot as yet be given, the following advantages have been noted several times by different laboratories giving justification for establishing and supporting this program. Rubber modifies the behavior of asphaltic binders in a number of ways: 1) The softening point is raised which results in less flow at high road temperatures; 2) the brittle point is lowered and therefore less cracking results at low temperatures; 3) elastic properties are imparted to the asphalt. Road trials have shown the advantages obtained from using a rubberized asphalt in different types of surfacing. In surface dressing, for example, normal asphalt binders tend to "fat-up" under heavy traffic at high temperatures. The addition of rubber prevents this because of the reduced temperature susceptibility of the binder. Also, the rubberized binder holds the stones more tenaciously, resulting in a greater stone coverage. When mixed materials are used, one of the most important results obtained by adding rubber is the resistance to cracking. This is particularly evident when the surfacing is used on a weak base, or over concrete, when cracks occur over the joints due to the movement of adjoining slabs.

Aside from the use of rubber in roads, the following areas show promise as large outlets for waste rubber. Reservoir linings made of reclaimed rubber sheets retain water much like the plastic sheeting now being used. Jetty and sea wall coating, a blend of asphalt and reclaimed rubber may help to lower maintenance costs on these constructions. They may also help to check soil erosion. The same blend can be used in place of reclaim rubber sheets in reservoir linings, culverts, and drainage ditches. Rubber and asphalt with and without scrap tire fiber can also be used for roofing and siding applications. Fiber, the by-product from the fiber separation system of the reclaimers, can be used as insulation board for buildings and truck bodies, mulch for new grass plantings along highways, polymer recovery, fuel for incinerators, filler for adding to concrete foundation and roads, and as a low cost construction material when coated with asphalt. Worn tires, reclaimed rubber slabs or molded reclaim rubber can be used as highway guard rails and impact absorbers and crumb rubber can be used as the cushioning media.

The pyrolysis or destructive distillation of rubber has been successfully accomplished resulting in products ranging from fuel gas to oils to tars. A preliminary review of these products suggest no present economic capability to compete with new products. Use of this distillate in competition with presently used oils for extending various new rubbers would necessitate a low cost of the magnitude of 2-3 cents per pound.

The possibility of the distillate being used as a starting material for synthesis in the chemical industry, is complicated by the multiplicity of products or components obtained with pyrolysis. It may be possible to exert more control over the formation of these products through the use of selected catalysts. However these catalysts will have to exhibit broad activity in order to function with the multiplicity of rubber types in service; including all the added chemicals, curing agents and oils.

Section VI

Conclusions and Recommendations for Further Action

Since nearly 41% of the solid rubber waste consists of worn-out tires, solution of this segment of the problem will greatly alleviate the overall disposal situation. The directions that further work on this part of the solid waste problem should take are incorporated in the recommendations below.

1. The *logistics* of rubber scrap collection with emphasis on scrap tires is the first essential. Tires are so widely distributed, so obvious, and so large in annual volume that the primary need is to gather them in sufficient concentration that economical facilities may be constructed for their management and to ensure that they substantially disappear from the general environment. Probably the best way of studying the logistics of collection would be through a study on the logistics of original distribution in cooperation with the tire industry. The tire manufacturers and distributors devised a system for getting tires to the point of use at a minimum cost within a profit oriented structure. There will be much to learn here as to the best system to use to return the scattered scrap tires to new points of concentration. Perhaps the identical or closely similar chain of operation could be used in reverse at minimum cost. That is retailer, jobber, distributor, and warehouser.

The logistics almost certainly require a local collection system, reduction of bulk by chopping, establishment of fair minimum rail and truck tariffs and regulations for transportation to collection centers and establishment of proper facilities at those centers.

2. *Facilities* need to be developed for efficient and controlled conversion of rubber waste. As with any waste, no conversion system can make rubber solid waste disappear but can only convert it to a less objectionable or possibly useful form. Proper and practical performance standards on any disposal method must be established promptly, on an interim basis if necessary, so that obsolescence by statutory action will not further complicate the problem. Incineration appears to offer the best present conversion method as it can result in major reduction of solid waste with the potential production of heat, steam and possibly power. It also has the vast technology of furnace and boiler design as a starting point. The high heat of combustion, the generation of noxious sulfur, nitrogen, and other gases, and the relatively high content of metal and ash will make this a difficult design problem which probably will require financial support at the beginning.

3. *Other conversion* means have been suggested such as the pyrolysis work of the Bureau of Mines with the Firestone Tire and Rubber Co. or chemical or biochemical processes. These do not offer as quick or as economically feasible solutions in the short run but they appear to be deserving of continuing supported research. Centralized facilities for collection and combustion of scrap would offer ideal support for pilot operations of advanced conversion studies.

4. *Densification* of tires and other rubber waste is essential whether they are to be disposed of in local land fill, burned in local incinerators, or shipped to centralized collection centers. This densification requires only cutting and chopping to less than one inch size and can be done with existing unit equipment. Supported efforts should be directed to the design of pilot systems, preferably portable, which will do this size reduction cheaply, with minimum investment, minimum labor input, and sufficiently rugged to operate outdoors in rugged terrain and with little or no special maintenance.

5. Waste rubber in roads is a matter which calls for serious study. Much of the work which has been done in the past has been less than definitive and much has been based on the addition of new rubber or rubber latices, which may be useful but is irrelevant to the problem of solid waste disposal. It is estimated that at a 5% usage of rubber waste in all new asphalt paving, the national demand would be equivalent to the current generation of waste rubber tires. Studies in this important potential usage, restricted to ground cured rubber or reclaimed rubber, should incorporate:

a. Feasibility studies on the incorporation of rubber materials in asphalts and in hot or cold mix plants.

b. Determination of optimum levels of waste rubber addition.

c. Initiation of long term studies of the service improvement value, if any, of such additions to pavings in actual installations.

d. The logistics of supplying the waste rubber in usable form where needed.

e. The extension of the use of cured waste or reclaimed rubber in asphalt to public play grounds, tracks, courts, parking areas, and curbing or other barriers.

6. The Bureau of Solid Waste Management could maintain continuing surveillance over federal, state, and local legislation, industry standards, consumer demands, and technological changes to ensure that such programs and regulations do not inadvertently and unnecessarily exaggerate the scrap rubber problem by limiting the service life of rubber products. This could comprise, among other things, tire safety standards, retreading standards, highway speed maximums, highway construction standards, axle-load standards, tire overload standards for original equipment, industrial safety standards involving belts, hose, cable and personal protective equipment. Although such action for the public is intended for beneficial purposes there is always the possibility that through over-enthusiasm or lack of information the actual service life of tires and other rubber products may be reduced to the extent that the solid waste problem is seriously aggravated. The Bureau of Solids Waste Management should be prepared to advise on such public actions before they are given final form.

7. Waste rubber, particularly tires, could possibly be used as protective barriers on the nation's motorways. Either in the form of whole tires or ground rubber in containers, they could be effective impact absorbers at underpasses, median barriers or land cuts.

Appendix I Glossary

Adjusted Tires
Tires that have passed initial manufacturers inspection but are revealed after use, to be unfit. They are returned to the dealer for compensation.

Clean Outs
Residual rubber left in machinery from prior runs which is removed and discarded.

Factory Wastes
Floor sweepings, polymer removed for testing and later discarded, etc.

Innerliner
An integral inside tire layer for improved air retention.

Mechanical Products Scrap
Products rejected by producer as being unfit for use due to manufacturing defects.

Nerve
A generic term used to denote the "springiness" of a polymer. Usually used when referring to the uncompounded polymer.

Off-the-road-tires
Tires which are larger than normal bus and trailer truck tires such as found on large earth moving equipment.

Other (as used in Table II-4)
Primarily selvage and portions of rubber polymer removed for testing.

Peelings, Fabric Free
Strips of tread which have been peeled off worn tires.

Polymer
A chemical compound formed by combining small molecules or atoms into long chains of essentially repeating structural units.

Raw Polymer
A polymer which has not been mixed with compounding ingredients such as curing agents and softeners.

Rejected Tires
Tires rejected by a producer as being unfit for use due to manufacturing defects.

Retread Buffings
The crumb rubber produced when a retreader grinds off the remaining tread from a worn tire before applying a new tread.

Rubber
A general term for polymer compound, and products.

Rubber Compounds
As used in this report, rubber compound refers to the polymer mixed with fillers, oils and curing agents.

Rubber Latex (latices)
A milky or tan colored solution consisting of rubber in water.

Safety Barriers
Separate liners placed inside tires to seal punctures and leaks which occur during road use. The liner may be a contaminant of reclaim or else it presents a manufacturing difficulty to the industry.

Scrap
Manufactured rubber articles or parts rejected or discarded and useful only as material for reprocessing.

Selvage
A border or edge trimmed off a molded part; also, that portion of a sheet of rubber which remains after parts are die-cut out.

Square Woven Duck
Fabric consisting of threads woven perpendicularly i.e. equal amounts of weft and warp.

Tire Parts
Tire selvage usually from the splitting industry.

Tire/Tire Products
Tires, innertubes, rubber curing bags and other products relating to tires or their manufacture, renovation or repair.

Waste
Rubber articles which through wear or contamination are disposed of as being of no further use.

Weftless Cord
A woven fabric in which the weft threads are replaced by a limited number of very thin threads.

Bibliography

This portion contains an alphabetical list of the oils and chemicals used or investigated by the reclaiming industry. Alongside each item, in italics, is the name of the person or organization that published data pertaining to the item. The periodical the data appears in will be listed under the person's name in the second section.

Accelerators *Khodevitch, L.*

Acid, abietic *Treves, A.*

Acid, Aliphatic, unsaturated derivatives *Tsvetaeva, E.M.*

Acid, benzoic *Amphlett, P.H., Hughes, A.J., Twiss, D.F.*

Acid, carboxylic *Wingfoot Corp.*

Acid, carboxylic, anhydrides *Drozdovskii, V.F., et al*

Acid, cresylic, petroleum, sulfide of *Smith, G.E.P., Jr.*

Acid, Dithiocarbamic *(1) Cech, C.J., Bata, A. -G. (2) Regie Nationale Des Usines Renault (3) Bata, A. -G. (4) Yaroslav, C.*

Acid, fatty *(1) Lebeau, D.S. (2) Tsveteava, E.M. (3) Rein-Chemie G.m.b.h.*

Acid, formic *Rubber Reclaiming Co.*

Acid, Hydrochloric *(1) Hudecek, J., Dlab, J. (2) Dasher, P.J.*

Acid, mineral *(1) Pearson, W.L., Schweller, H.E. (2) Dasher, P.J.*

Acid, napthenic *See Napthenic Acids*

Acid, organic *Kirby, W.G., Elliott, P.M.*

Acid, organic, polyglycol esters of *Saul, W., Wiggins, T.J.*

Acid, organic, zinc or aluminum salt of *Johnson, T.A.*

Acid, Phosphoric *Kelly, J.H., Jr.*

Acid, Phospheric, alkyl salt *Kelly, J.H., Jr.*

Acid, Phosphoric, alkyl *Kelly, J.H., Jr.*

Acid, sulfuric, conc. *Naftolen Gesellschaft*

Acid, sulfuric, dil. *Semperit Gummiwerk G.P.*

Acid, sylvic *Treves, A.*

Acid, tar, by-products *Metallgesellschaft, A. -G.*

Acid, thioglycoltic, B-napthalide of *Drozdovskii, V.F.*

Activator, surface *Sanyou, Yushi Kogyo Co.*

Activator, sulfur containing *Drozdovskii, V.F.*

Additives *Dufour, R., Leduc*

Agents, devulcanizing (list) *Oil, Paint and Drug Reptr., 141: p. 60 (May 25, 1942)*

Agents, non-stain *Keilen, J.J., Dougherty, W.K.*

Agents, softening, soling waste *Mishustin, I.U.*

Agents, swelling *Rivier, A., Dietzel, E.*

Agents, swelling, cracking aid *Reich, H.F.H.*

Agents, swelling, study *Rostler, K.S., White, R.M.*

Alcohols, aliphatic *Sartorelli, U.*

Alcohols, aliphatic, monhydric *Wingfoot Corp.*

Alcohol, ethyl *Moore, D.V., Thompson, H.H.*

Alcohol, n-butyl, w/steam *Bergmann, F., Dishon, B.R.*

Aldehyde *Mankowich, I.*

Alkali *Levin, M.*

Amide *Kirby, W.G., Elliott, P.M.*

Amine, aliphatic *Smith, G.E.P., Jr., Bennett, R.B.*

Amine, aliphatic, water insoluble *Kelly, J.H., Jr.*

Amine, alkylol *Dasher, P.J.*

Amine, hydroxyl– *Dasher, P.J.*

Amine, hydroxyl–, (or salt) *Dasher, P.J.*

Amine, mercapto– *Dasher, P.J.*

Amine, napthyl, phenyl-beta- *Johnson, T.A., Thompson, H.H.*

Amine, poly–, aliphatic *Dasher, P.J.*

Amine, secondary, polycyclic *DeWaele, A.*

Amine, Tri–, diethylene *VanValkenburgh, E.A.*

Ammonia *Joyce, W.T., Geyer, H.D.*

Ammonia, emulsions, w/reclaim *Radinger, E.J.*

Anhydride, maleic *Green, J.*

Anisates *Tsvetaeva, E.M.*

Aromatic, Hydrocarbons *Lambrino, V., et al*

Asphalt, residue *Kilbourne, F.L.*

Bentonite *Thompson, H.H.*

Benzene, chloronitro- *Schwerdetel, F.*

Benzene, nitrochloro- *I.G. Farbenindustrie*

Bitumen *(1) Ghez, H., Ghez, O. (2) Hermes Patentverwertungs, G.m.b.h. (3) Accumulatoren-Fabrik*

Borate *Flood, D.W.*

Bromides, thiosulfonyl *Proell, W.A.*

Carbazole, derivatives, sulfur containing *Drozdovskii, V.F., et al*

Carbon Black (all reclaim tread) *Continental Carbon Co.*

Carbon Black, (tread) *Cohan, L.H., Mackey, J.F.*

Carbonate, calcium *Bulli, M.*

Carbonate, sodium *Bulli, M.*

Catalysts *Drozkovskii, V.F.*

Catalyst, multivalent *Staten, F.W., Haines, W.M., Jr.*

Catalyst, plasticizing *Baudelot, P.*

Cellulose *Kirby, W.G., Steinle, L.E.*

Chloride, ammonium *Kirby, W.G.*

Chloride, di-, sulfur *Smith, G.E.P., Jr., Ambelang, J.C.*

Chloride, hydrogen *Kobrinskii, L.S.*

Chloride, hydrogen, anhydrous *Midland Silicones Ltd.*

Chloride, sulfonyl *Bata, A. -G.*

Chloride, sulfur *(1) Cook, W.S. (2), Hensley, W.A.*

Chloride, thiosulfonyl *Proell, W.A.*

Chloronitro, aromatic, compounds *I.G. Farbenindustrie*

Colophony *Treves, A.*

Copal *Treves. A.*

Cryptomeria *Kawashima, Y.*

Cyanates, thio-, organic *Drozdovskii, V.F., et al*

Cyclopentadiene *Boyd, J.H.*

Disulfide, aliphatic *Elgin, J.G.*

Disulfide, Alkyl, cresnol *Beloroxxova, A.G., Faberov, M.I.*

Disulfide, alkyl, phenol *Drozdovskii, V.F., et al*

Disulfide, aromatic *Schneider, P.*

Disulfide, benzothiazoyl *Yaroslav, C.*

Disulfide, carbon *Kawaoka, J.*

Disulfide, diaryl-, w/nitrated groups *I.G. Farbenindustrie*

Disulfide, dibenzothiazoyl *Bata, A. -G.*

Disulfide, di-(trichlorophelyl) *Drozdovskii, V.F.*

Disulfide, (effects) *Dogadkin, B.A., et al*

Disulfide, hydrocarbon *Tewksbury, L.B., Jr., Howland, L.H.*

Disulfide, hydroxyaryl *Kirby, W.G., Steinle, L.E.*

Disulfide, organic *Warren, S.F.*

Disulfide, Tert-butyl cresol *Beloroxxova, A.G., Farberov, M.I.*

Disulfide, Thiazoyl *Yaroslav, C.*

Dye, azo (non-stain) *Phoenix Gummiwerk A. -G.*

Ester, acrylic *Dasher, P.J.*

Esters, w/OH groups *Continental Gummiwerk*

Ether, dibenzyl *Satake, S., Tatebayashi, K.*

Factice *Morche, K., Ehrend, H.*

Fat, wool *Renneman, H., Gunzert, T.*

Fillers *Dufour, R., Leduc*

Formaldehyde *Mankowich, I.*

Furfural *Sakada, M.*

Gas, exhaust *Johnson, A.*

Gas, tars *Krivunchenko, N.G., et al*

Glycerin *Rebmann, A.*

Glycol, ethylene *Continental Gummiwerk*

Glycol, ethylene *Johnson, T.A., Thompson, H.H.*

Heptenes *Elgin, J.G., Sverdrup, E.F.*

Hexane *Tsveteava, E.M.*

Hexanol, polyalkylcyclo- *Cook, W.S.*

Hexenes *Elgin, J.G., Sverdrup, E.F.*

Hydrazine, monoacrylo- *I.G. Farbenindustrie*

Hydrazine, monoaryl- *(1) Gumlich, W. (2) I.G. Farbenindustrie (3) Bachle, O.*

Hydrides, metalloid (butyl) *Baldwin, F.P.*

Hydrocarbons, aromatic, Oxidised *Lorand, E.J.*

Hydroxide, sodium *Neal, A.M., Schaeffer, J.R.*

Irradiation, radioactive *Drozdovskii, V.F., et al*

Kerosine *Al'tzitser, V.S., Tugov, I.I.*

Lampblack *Dubrovin, G.I.*

Material, surface-active *Bruckner, Z., Juhasz, M.*

Metal, heavy, salts of *Rein-Chemi G.m.b.h.*

Metal, molten, alloy bath *Kelefti, Z.*

Mercaptans, (effects) *Dogadkin, B.A., et al*

Mercaptans, aliphatic *Elgin, J.G.*

Mercaptans, aromatic *(1) Ecker, R., Gumlich, W. (2) Schneider, P. (3) I.G. Farbenindustrie*

Mercaptans, aromatic, w/ammonia salts-amine salts of acids *Bahr, K., Schmidt, K.*

Mercaptan, benzyl *Mersereau, J.M., Mester, P.J.*

Mercaptan, tertiary lauryl *Warren, S.F.*

Mercaptoamine *Dasher, P.J.*

Naptha *Corkery, F.W.*

Naptha, extraction of isobutylene with *Sparks, W.J., Baldeshwieler, E.L.*

Naptha, solvent *LeBeau, D.S.*

Napthalene *Studio Chemico Industriale*

Napthalene, tetrahydro *Renneman, H., Gunzert, T.*

Napthenates *Amphlett, P.H., Hughes, A.T., Twiss, D.*

Napthenic, hydrocarbons *Lambrino, V., et al*

Napthols, dialkyl- *Hensley, W.A.*

Nitrite, sodium *LeBeau, D.S.*

Octanes *Elgin, J.G., Sverdrup, E.F.*

Oils (list) *Oil, Paint and Drug Reptr., 142: no. 15, p. 44. (October 12, 1942)*

Oil *Deutsche, Shell A. -G Metallgesellshaft A. -G.*

Oil, anthracene *Spocete, A.*

Oil, arabic, lubricating *Asano, T., Kusunoski, S.*

Oil, aromatic, w/naptha *Corkery, F.W.*

Oil, fish *Endo, H.*

Oil, hemp seed *Syui-Chzhou, Li.*

Oil, mineral, oxidized *Polyplast Gesellschaft Fur Kautschukchemie*

Oil, napthenic *Nicolaisen, B.H.*

Oil, paraffin *Oblocynzsky, J.*

Oil, reclaiming *(1) Beaven, E.W.J. (2) Beverly, J.A. (3) Campbell, C.H., Ostermayer, R.W. (4) Van Valkenburgh, E.A.*

Oil, resin, grey tower *Randall, R.L.*

Oil, resin, reclaiming *Campbell, C.H.*

Oil, Rosin, (non-stain) *Brown, G.L., Johnson, T.A., Knill, R.B.*

Oil, Schist, w/NR *Bechtold, H.A.*

Oil, shale *Tsveteava, E.M.*

Oil, soybean *Sugimoto, S., Minamikata, I., Sakai, K.*

Oil, sulfur, mix *Clayton, R.E.*

Oil, Tall *Van Valkenburgh, E.A.*

Oil, tall *Zachesova, G.N., et al*

Oil, tall, oxidized *White, C.M.*

Oil, tall, sulfurized *Nicolaisen, B.H.*

Oil, tar, solvent *Osipovsky, B.Y., et al*

Oil, vegetable *Endo, H.*

Olamine, alkyl- *Clarke, R.B.F.E.*

Oleate, triethylamine *Polyplast Gesellschaft Fur Kautschukchemie*

Olefin, copolymers *Montecatini, Soc. Gen.*

Oxidants *Zaionchkovskii, A.D., et al*

Oxygen *(1) Bennett, R.B., Smith, G.E.P. (2) Essex, W.G. (3) Gibbons, P.A.*

Oxygenic, pro- *Haehle, A.*

Paraffins *Campbell, A.W.*

Paraffinic, hydrocarbons *Lambrino, V., et al*

Peptizer *(1) Castello, A.D. (2) Drozdovskii, V.F., et al*

Peroxide, hydrogen *Amphlett, P.H., Hughes, A.J., Twiss, D.F.*

Peroxide, Hydro-, a,a-di-alkylarylmethyl *Lewis, J.R.*

Peroxides, Organic *Continental Gummi Werk*

Phenol *Smith, G.E.P., Jr., Ambelang, J.C.*

Phenol, thio *(1) Drozdovskii, V.F., et al (2) Garvey, B.S. (3) Neal, A.M., Schaeffer, J.R. (4) Rebmann, A.*

Phenol, trichloro- *Vinitskii, L.E., Litovchenko, M.P.*

Phenol, trichlorothio- *(1) Drozdovskii, V.F., et al (2) Shokin, I.A.*

Phenol, trichlorothio-, disulfide of *Drozdovskii, V.F., et al*

Phenol, trichlorothio-, zinc salt of *Drozdovskii, V.F., et al*

Phosphates, alkyl *Kelly, J.H., Jr.*

Phosphine, triphenyl- *Drozdovskii, V.F.*

Pigments *Westhead, J.*

Plasticizers *Ceva, A., Trius, V.*

Polymer, high styrene, reclaiming in presence of *Sverdrup, E.F.*

Products, petroleum for rubber *Standard Oil Co.*

Propane *Tsveteava, E.M.*

Propylene, poly-, atactic *White, R.A.*

Reagents (list) *Oil, Paint and Drug Reptr., 142: No. 3, p. 44 (July 20, 1942)*

Reclaiming Agents (synthetic rubber) *Cook, W.S., Albert, H.E., Kilborne, F.L., Smith, G.E.P.*

Reclaim, non-stain, w/soap *Castello, A.D., Dixon, H.L.*

Resins *Patel, M.U.*

Resin, Coumarone *(1) Kenneman, H., Gunzert, T. (2) Spocete, A. (3) Treves, A.*

Resin, gas generating *Krivunchenko, N.G., et al*

Resin, Phenol, formaldehyde *(1) Dinzburg, D.N. (2) Haang, C.Y., Tanabe, H.*

Resin, pine *Syui-Chzhou, Li.*

Resin, pine, wood *(1) Naudain, E.A., Bays, C.H. (2) Ray, P.A.*

Resin, pine, tar *Tsi-Te, Ku.*

Rosin *Zachesova, G.N., et al*

Rosin, pine *Liverovskii, A.A., et al*

Rhodanides, alkali *Ecker, R., Bahr, K.*

Selenide, aryl *Wheeler, G.P.*

Sensitizers, heat *Campbell, A.W.*

Shale *Tsveteava, E.M.*

Siloxanes, diorganopoly-, acyloxy end blocked *Bruner, L.B.*

Softeners *(1) Nikolaev, N.V., et al (2) Sugino, K. (3) Tsveteava, E.M.*

Solvent *Jaeger, R.W.*

Solvent, naptha *Kilbourne, F.L.*

Spirit, white *Al'tzitser, V.S., Tugov, I.I.*

Sulfides, aromatic, armine, N,N-Dialkyl *Albert, H.E., Ambelang, J.C.*

Sulfide, arylamide *Webb, E.J., et al*

Sulfide, dicresol *Albert, H.E.*

Sulfide, dixylyl *Higgins, C.J., Forman, D.B.*

Sulfide, mono-, Bis(tetraalkylphenol) *Cook, W.S., Smith, G.E.P., Jr.*

Sulfide, tetraalkylphenol *Cook, W.S., Smith, G.E.P., Jr.*

Sulfide, thiazyl *Bata, A.G.*

Sulfide, Thiuram *(1) Bata, A.G. (2) Yaroslav, C.*

Sulfide, zinc *Stafford, W.E., et al*

Sulfite, pulp *Sarada, M.*

Sulfoxide, bis, phenol *Cook, W.S.*

Sulfoxide, bis (4,6-di-tert-butyl-3-methylphenol) *Cook, W.S.*

Sugar *Kirby, W.G., Steinle, L.E.*

Swellers (list) *Oil, Paint and Drug Reptr., 142: No. 16, p. 71, (October 19, 1942)*

Tarr, coal *Spocete, A.*

Tar, coal, distillate *Wingfoot Corp.*

Tars, gas *Krivunchenko, N.G., et al*

Tar, lignite *Kuznetson, V.I., et al*

Tar, pine *(1) Amphlett, P.H., Hughes, A.J., Twiss, D.F. (2) Berryman, G.C. (3) Solokov, S.A., et al*

Thiazole *(1) Bata, A.G. (2) Cech, C.J., Bata, A.G. (3) Yaroslav, C.*

Thiazole, mercaptobenzo- *(1) Amphlett, P.H., Hughes, A.J., Twiss, D.F. (2) Kawaoka, Y.*

Thiol, aromatic *Gumlich, W., Ecker, R.*

Thiophene (ring) *Sverdrup, E.F.*

Toluene, thiophene *Kimishima, T.*

Urea, phenylthio *Kawaoka, Y.*

Utanol *See Utanol*

Application and Uses of Reclaimed Rubber

Adinoff, S. Manufacture and properties of rubber adhesives. R.A. (N.Y.), 49: pp. 171-72, 204 (June 1941). Natural and reclaimed rubber cements.

Anon. Using old rub. stocks Vol. 143 No. 10 page 362 yr 62 Ln. 2 Rub Pl Wk

Bobyl'knov, M.I., Tabachnik, E.I., and Shevyreva, L.P. Reclaiming and Manufacture of Brake Linings from Scrap and Worn-Out Linings. Kauchuk i Rezina, No. 5, pp. 67-71 (1938). (21 lines in C.A., 32:7605; S.C.L. 16:793).

Bowler, R.P. Disposable tire treads. U.S. Pat. 3,007,506 (Nov. 7, 1961). (To J.P. Malone Co.)

Busenberg, E.B. Reclaimed rubber in tires and other transportation items. (Abstract only). Rubber Age, 83: p. 854 (1958). (R.A., 36:526). The use of reclaimed rubber in carcass compounds.

Carpmael, M.H. Recovery of rubber. Brit Pat. 602,725 (1948). (To Manufacture de Caoutchouc Michelin, Puiseux, Boulanger et Cie). (S.C.L., 26:727). Ground scrap rubber mixed with new rubber stock.

Cattania, U. Water impermeable sheets. Swiss Pat. 214,410 (C.A., 36:3340; S.C.L. 20:318). Consisting of reclaim and bitumen.

C.K. Reclaimed rubber as a substitute for raw rubber. Tech. Handel, 27: p. 199 (1937). (S.C.L., 16:45).

Crawford, R.A. Composition of matter. U.S. Pat. 2,265,770 (Dec. 9, 1941). (To Goodrich). Spongy, sound-deadening composition comprising reclaimed rubber asphalt, wood flour and rosin.

Demidov, G.K. Manufacture of roofing material and other articles from scrap materials of tire production. Kauchuk i Rezina 19 (4), 45-7 (1960); Soviet Rubber Technol 19 (4), 42-4 (1960) (R.A., 39:122).

DPR, Inc. Pourable rubber. Rubber World, 148: 7 (1963). (R.A., 41: 405). A specially compounded depolymerized rubber can be used to make poured-in-place gaskets for half the cost of cut-out gum gaskets.

Earnest S.A. Hovland L. W. Minford J.D. Mach. Design, 39, no. 2, Jan. 67, p 192 Adhesives for aluminum. Compositions involving reclaim are discussed.

Ehrend, H. Use of special reclaim in SBR stocks. Gummi, Asbest, Kunststoffe 15 (9), 818,822,824-9 (1962). (R.A., 40:580).

Ehrend, H. Use of Reclaim in cpds Gum Asbest Vol. 15 No. 9, Page 818, Yr. 62 Ln 12.

Engelbach, T.J. Solid Composite propellants prepared from depolymerized rubber. U.S. Pat. 2,953,446 (Sept. 20, 1960). (C.A., 55:2108; R.A., 39; 195).

Esman, P. I. Use of reclaim. Kauchuk i Rezina, 18: No. 2, pp. 54-55 (1959); trans. in Soviet Rubber Tech., 18: No. 2, p. 56 1959. (R.A., 37:428). Conveyor belts.

Fischer, R. Utilization of used rubber. German Pat. 854,258 (Aug. 28, 1952). (R.A., 31:309).

Garner, T.L. Use of Reclaimed and Waste Rubber in Rubber Compounding. Chem. Age, 41: pp. 22-23 (1939). (S.C.L., 17:547).

Garvick, K.R. Reclaimed rubber in pneumatic tires and tubes. Rubber Age N.Y. 89 (2), 304 (1961). (R.A., 39:391). A review.

Gryzlova T.A. Sinyaev V.P. Izv. Vyssh. Uchebn Zaved Tecknol no. 5 1965 p 33. Investigations into the use of reclaim on the formulations for feathery and light porous sole vulcanizates.

Hardman, K.V. and Lang, A.J. Properties, uses and compounding of depolymerized rubber. Wire Prod. 1962 (Apr). 484-90. (R.A., 40:446). Applications to the electrical trade.

Hess, E.F. Honeycomb adhesives Vol. 18 No. 2 Page 12 yr 60 Ln. 4 Plas World

Heyman, J. Reclaiming of vulcanized rubber scrap. French Pat. 1,015,924 (Oct. 28, 1952). (R.A., 31:217; Rev. Gen. Caout., 30:134). Powdered scrap is mixed with latex.

Hublin, R.A. Evaluation of Mixings Containing Reclaim. Rev. Gen. Caout 16: pp. 297-302, 329-35 (Oct. and Nov., 1939). (S.C.L., 18:32).

Imperial Chemical Industries, Ltd. Use of reclaimed rubber for adhesive solutions and cements. (Technical Report). (S.C.L., 20:282).

Jackson, B.S. Rubber J., 148, No. 9, Sept. 1966 p 46 Making use of rubberlike materials in building sealants. Types, properties and test methods.

Katz, I. Gov. Specs-Adhesives Adhes. Age Vol. 8 No. 2 Page 24 Yr 65 Ln 8

Kujawa B. and Penczek A. Adhesive for Floor Covering Based on Reclaimed Rubber Plasteau Kaut 12, no. 8, Aug. 65-p487.

Levitin, I. New Use For Reclaim Sov. Rub. T. Vol. 21 No. 11 Page 39 Yr 62 Ln. 2.

Macy, J.H. Reuse of vulcanized scrap synthetic rubber. U.S. Pat. 2,378,717 (June 19, 1945). (To Goodrich). (C.A., 39:3966; S.C.L., 23:370). Grinding the scrap, mixing it with an unvulcanized copolymer of 1,3-butadiene and acrylonitile or styrene, and vulcanizing the mixture.

Manufacture de Caoutchouc Michelin (Puiseaux, Boulanger et Cie). Rubber articles containing used rubber. Netherlands. Pat. 67,986 (May 16, 1951). (S.C.L., 29:661). Used rubber in Polyhedral fragments.

Marr, R.B. Rubber in the paper industry. Pulp Paper Mag. Can., 41: pp. 439-44 (June, 1940)

Midwest Rubber Reclaiming Co. Reclaim in a first quality "cold" rubber tread-a road test. (Booklet) (C.A., 45:6422; S.C.L., 28: 195).

Moncrieff, R.W. Plastics, 30 no. 336, Oct. 1965 p 79 Structural Reinforcement of polyurethane foams with reclaimed scrap.

Mysona, M. Golebiowski, T. and Sliwa, T. Use of scrap rubber as a filler for phenol-formaldehyde molding compounds. Plaste Kautschuk, 11(8):479-80 (1964). (R.A., 42:638).

Palmer, H.F. Use of reclaimed rubber in mechanical and hard rubber goods. R.A. (N.Y.), 47: pp. 249-51 (July, 1940).

Peik, P.G. Sound deadener. U.S. Pats. 2,240,014 and 2,240,015 (Apr., 1941). Of rubber and reclaimed rubber.

Plumb, J.S. Use of reclaimed rubber in sponge rubber goods. R.A. (N.Y.), 47: pp. 165-55 (June, 1940).

Preparation of Water Dispersions of Raw Rubber, Reclaim, Substitutes, and Bituminous Substances. G.Z., 52: pp. 407-09, 430-31 (1938). (S.C.L., 16:501,694; B.C.A. (B), 696-1938).

Reclaimed rubber in code wire insulation stocks. Vanderbilt News, 7: No. 4, pp. 16-17 (July-Aug., 1937).

Reclaimed rubber in friction and coat stocks. Vanderbilt News, 7: No. 4 pp. 6-9 (July-Aug. 1937).

Reclaimed rubber in tire tread or belt cover stocks. Vanderbilt News, 7: No. 4, pp. 10-11 (July-Aug., 1937).

Rubber Cement Products, Ltd., and Watts, RHP Plastics compositions. Brit. Pat. 537,135 (June 10, 1941). (C.A., 36:1807). Mixtures of compounded latex with Portland cement, sand, and granulated cork, troweled out in sheets of 1/8th of an inch thickness and vulcanized.

Rubber Couplings in Swedish Railroads vol. 20, no. 2, 1967, p. 65 (NR)

Rubber Developments vol. 20, no. 1, 1967, p 26 (14" x 4" x 1 pads) (NR) Roadside Safety Fencing Shock Absorbers.

Rubber Developments vol. 19, no. 4, 1966, p 135 (surfacing method) (NR) Natural Rubber for Severn Bridge Surfacing.

Rubber Developments vol. 20, no. 2, 1967, p. 61 (850 lbs/units) (NR) Marine Dock Fenders.

Rubtex Rubber Products. R.A. (N.Y.). 42: p.318 (Feb. 1938). (S.C.L., 16:764). See Also: A New Method of Utilizing Reclaimed Rubber (Rubtex) in Rev. Gen. Caout., 15: No. 138, p. 24 (Jan., 1938).

Shanker, U. Liquid rubber. Rubber News 1 (3), 29-30 (1961). R.A. 40:446)

Shokhin, I. and Smirnov. A. Structural material from scrap rubber Stroital. Materialy, 2: No. 10, pp. 9-11 (1956). (C.A., 51: 10110; R.A., 35:521). Asbestos-ebonite tiles.

Snell, F.D., Inc. Use of depolymerized rubber. I.R.W., 122: p. 69 (1950). (S.C.L., 28;523). As a plasticizer for natural rubber.

Sumkin, V. Reclaimed rubber containing lead oxide from rubber used for x-ray rubber goods. J. Rub. Ind. (U.S.S.R.), 12:1059-60 (1935). (C.A., 30:6603).

Testworth Laboratories. Reclaim rubber compounds as substitutes for latex. Chem. Eng. News 21: p. 692 (May 10, 1943). Including a specially formulated compound of reclaim rubber emulsion which saved 40% of the reclaim by substitution.

Thoillet, R., and Haehl, A. Designing compounds based on reclaim. Rev. Gen. Caout., 18: pp. 163-70 (1941). (S.C.L., 20:185; Chem. Zentr., 113: Pt.I:546).

Trivedi, N.N. Rubber Footwear I Vol. 19 No. 1 Page 23 Jan. 1967 Len. 7 Lang. Eng. Rubber India.

Twiss, S.B. Adhesive Use in Autos Adhes. Age. Vol. 6, No. 12, Page 16, Yr. 63 Ln. 7.

Uses of reclaimed rubber. I.R.J., 99:pp.57-58 (1940). (S.C.L., 18:32) Brief review.

Westhead, J. and Bloxham, J.L. Applications of reclaimed rubber. Rubber Plastics Weekly 140 (16), 607-8 (1961). (R.A., 39:345). The advantages and disadvantages are discussed.

Whelan, L.A. Field experiments on Dartonfield Estate. XXIV. Maturing experiment with mature rubber (1943). Rub. Res. Scheme Ceylon, Quarterly Circular, 21: pp. 6-8 (1944). (S.C.L., 23:250).

Whelan, L.A. and deSilva, C.A. Field experiments on Dartonfield Estate. XX1. Manuring experiment with mature rubber. XX11. Growth of replanted areas. Rub. Res. Scheme Ceylon, Quarterly Circular, 20: pp. 10-14 (1943).

Development of Reclaimed Rubber

Alexander, P. Methods of Reclaiming Rubber Employed during the Past Hundred Years. "Proc. Rub. Tech. Conf., 1938", pp. 516-24. Repr. in I.R.J., 96: pp. 780-83 (Dec. 31, 1938). (S.C.L., 16:296).

Anon. Modern Reclaim Installations in the Rubber and Plastics Industry. Gummi Asbest Kunstst 18, 5 May 65 p 552.

Ball, J.M. Recent rubber industry developments in reclaimed rubber. I.R.W., 122: pp. 58-59 (1950). (C.A., 44:5131; S.C.L., 28:562)

Chadwick J. the use of reclaim under modern conditions. Proc. Inst. Rubber Incl. (42) p 15 (1966) General Discussion See also IR News Vol. 5 8 p 28 May (1966)

Fritton, W.J. Recent advances in reclaimed rubber. Rubber Age (N.Y.), 94 (2): 282-5 (1963). (R.A., 42:115). Advantages of reclaim are described.

LeBeau, D.S. Rubber Chem. Tech. 40, no. 1, Feb. 67 p 217-37. Science and Technology of Reclaimed Rubber, Developments over past twenty years.

Pariente, C., and Rohrer, P. Recent reclaim progress. Bull Tech. Perodique Franterre, No. 10: pp. 1-9 (1953). (R.A., 32:356). The pan, Lancaster and dip processes.

Stafford, W.E., and Wright, R.A. Progress in rubber reclaiming. R.A. (London), 31: pp. 19-21 (1950); Rubber India, 2: No. 1, pp. 22-24 (1950). (C.A., 44:5140; S.C.L., 28:303)

Stafford W.E. Armstead B.H. Present Day Manufacture of Reclaim Proc. IRI 12, no. 5 Oct. 65 p 208-18 Processes are discussed and compared. ((41) p 208 (1965))

Stafford, W.E. Standardization of reclaim, Trans. Inst. Rubber Ind. 17 pp. 268-71 (Feb. 1942). (C.A., 36:6046)

Stafford, W.E., and Chadwick, J. Recent advances in reclaiming Rubber & Plastics Age, 40: No. 10, pp. 1070-74 (1959). (R.A., 38:42). General discussion.

Stafford, W.E. Present trends in reclaiming. Rubber & Plastics Age 39: pp. 495, 497-98 (1958). (C.A., 52:19221:R.A., 36:455). The ratio of reclaimed rubber used to total natural and synthetic rubbers consumed is listed.

U.S. Rubber Reclaiming Co. Reclaiming rubber. Rubber J. Int. Plast. 134: pp. 65-66 (1958). (R.A., 36:110). Designed for low-cost manufacturing.

Digestion/Devulcanization of Reclaimed Rubber

Bowers, P.D. Improve reclaiming process. R.A. (N.Y.) 55:p.392 (1944). (S.C.L. 22:394). Steam at very high pressure.

Butera, G. Rubber reclaiming, French Pat. 1,1C3,627 (Nov. 4, 1955). (To Pirelli S.P.A.) (Rev. Gen Caout., 33:230; C.A., 49:2110; R.A., 34:237) Steam heated with mechanical agitation.

Fabregat, M.P.Devulcanizing and regenerating vulcanized rubber. U.S. Pat. 2,543,315 (Feb. 28, 1951). (Same as Austrian Pat. 165,050: Swiss Pat. 265,272; French Pat. 942,041). (S.C.L., 27:723; 28:918; 29:444). Machine.

Farrel-Birmingham Co., Inc. New Banbury rubber reclaimer and devulcanizer R.A. (N.Y.), 66: p. 253 (1949); I.R.W., 121: p. 261 (1949). (S.C.L., 28:166).

Hirschberger, J. Method of reclaiming or regenerating rubber from rubber waste products. U.S. Pat. 2,313,146 (Mar. 9, 1943). (C.A., 37:5284). Charging unground rubber in an autoclave with high pressure steam at 700 lbs. per sq. in. and 490° C.

Lewis J., and Lewis, S.C. Reclaiming rubber. Brit. Pat. 569,659 (June 4, 1945) (C.A., 41:6074; S.C.L., 23:344). Scrap rubber is reclaimed by heating in steam under pressure at 230° to 270° C. and then air is kept excluded until the rubber cooled.

Livyi, G.V. Shurko, V.A. and Landa, I.M. Thermomechanical reclaiming of colored rubbers. Legkaya Prom., No. 7: p. 30 (1956). (R.A., 35:425).

Masse, T.J. Reclaiming rubber, Austrailian Pat. 110,487 (Apr. 29, 1940). (C.A. 36:2759; S.C.L. 20:318). Treating ground scrap with super-heated steam at 400-500° F. and atmospheric pressure for three to six hours.

Markiewicz, W.J. USP. 3272761 Method of Reclaiming Rubber. Improving digester process by warming then cooling the product in 0_2 free atmosphere.

Maurin, A. Protected reclaiming. Rev. Gen. Caout., 36: No. 5 pp. 671-73 (1959). (R.A. 37:482). Treating vulcanized rubber with plasticizers in an oxygen free oven.

Morozov, M.A. Centralized control of the process of reclaimed rubber. Kauchuk i Resina 20 (9) 50-1 (1961). (R.A., 40:446). Devulcanizing tread and carcass stock.

Naudain, E.A., and Boys, C.H. Pan process of reclaiming rubber U.S. Pat. 2,794,006 (May 28, 1957). (To Hercules Powder Co.). (C.A., 51:12534; R.A., 36:15). Petroleum hydrocarbon-insoluble pine wood resin.

Olanescu, G. Devulcanization and the role of softeners in the production of reclaim. Ind. Usoara (Bucharest), 9 (8): 304-5 (1962). (R.A., 41:512) Review of soviet work.

Patentverwertungs G.M.B.H. "Hermes". Thermal, oxidizing decomposition of artificial rubber (Buna S. Perbunan). Italian Pat. 394,812. (S.C.L., 23:371; Rev. Gen Caout., 21:92). Under a pressure of at least 9 atmospheres.

Plumb, J.S. New reclaimed rubber process demands automatic temperature controls. Taylor Technology, Winter (1951). (S.C.L., 29:488; R.A., 68:732)

Rennemann, H., and Gunzert, T. Reclaiming vulcanized synthetic rubber scrap. German Pat. 716,149 (Dec. 11, 1941). (C.A., 38:2524). By treating with softener and heating at over 200°C for a period insufficient to induce further polymerization.

Societa Italiana Pirelli. Regeneration of vulcanized rubber. French Pat. 865,077. (S.C.L., 23:382; Rev. Gen. Caout., 18;149) Scrap rubber is caused to absorb a swelling agent at a temperature below 50°C. introduced into an autoclave and heated to devulcanization temperature with a devulcanizing agent; the resulting product is dried and treated for the recovery of the swelling agent. See Brit. Pat. 533,769 (Feb. 19, 1941)

Solakian, H. Reclaiming of rubber. U.S. Pat. 2,317,491 (Apr. 27, 1943). (C.A., 37:6160). Immersing in water at devulcanizing temperature and under pressure.

Tefft, R.F. Treatment of rubber goods. U.S. Pat. 2,321,114 (June 8, 1943). (C.A., 37:6908). Recovering textile material by digesting at elevated temperature with sulfur, a reverting type vulcanization accelerator, and sufficient rubber solvent to dissolve the rubber.

Terzi, Attilio, Reclaiming rubber and a pressure heater for carrying out the process. Italian Pat. 394,692. (Kautschuk p. 70, Oct.-Nov., 1943).

Equipment For Reclaiming Rubber

Anon Kunstst Berater, 12, no. 3, March 1967, p. 178 Machinery for reclaiming film scrap.

Baramboim, N.K., and Chimil, A.M. Mechanical reclaim of colored rubbers Nauchn, Trudy. Mosk. Tekhn. Inst. Legk. Prom., pp. 18-23 (1958). (R.A., 37:507). Freezing the vulcanizate with liquid nitrogen and fragmenting on the mill.

Breenan P. Old Tires. Austin Magazine 1964, 38, #10 p 41-3. A dry rapid automated way to crumb rubber (United Reclaim Ltd) and some uses.

Condux – Werke H.A. Merges KG GP 1217753. Comminuting Mill for reclaiming waste Bulky Plastics Moldings eg. bowls etc.

Dasher P.J. Reducing scrap vulcanized rubber to finely divided particles U.S. Pat. 2,853,742 (Sept. 30, 1958). (To Dasher Rubber & Chemical Co.) (C.A. 53:3758; R.A. 37:236). The object of the invention is to reduce vulcanized scrap to a fine dry powder.

Gul. V.E. Gelperin, N.I., Kaplunov, YN. Shokhim, I.A., Vilnits, S.A. Ilin, N.S., and Tsarskii, L.N. Comminution of vulcanized rubber articles. Russian Pat. 110,973 (May 27, 1958). (R.A., 36:407). Cooled to -60 to -80°C before being comminuted.

Gul. V.E. Vil'ntis, S.A. Gel'pebin, N.I. Ilin N.S. Kaplunov, Y.N., Tsarskil, L.N. and Krsikova, G.Z. Developing a method of grinding cooled rubbers Kauchuk i Rezina 17: No. 10, pp. 22-28 (1958). (R.A., 37:252). Experiments on used car treads.

Gunther, A. Process for reclaiming rubber. U.S. Pat. 2,794,057 (May 28, 1957) (C.A., 51:12533). Grinding and treating with a swelling agent.

Jaeckering, G. Pulverising and comminuting thermoplastic material Brit. Pat. 915,255 (Jan. 9, 1963). (R.A., 41:230). The precrushed material is whirled and comminuted in a gas flow, with at least 30,000 parts by volume of gas at atmospheric pressure per part by volume of starting material, the treatment time being not more than 1.2 sec.

Jayne, W.M. USP 3190565 Process for Grinding Rubber. Materials which tend to agglomerate are ground with polyolefin fines.

Joyce, W.J., and Geyer, H.D. Shredding rubber. U.S. Pat. 2,318,693 (May 11, 1943). (C.A., 37:6157; S.C.L., 21:211. Explosion with ammonia.

Knowland, T. M. Grinding of rubber scrap. U. S. Pat. 2,412,586 (Dec. 17, 1946). (To Boston Woven Hose & Rubber Co.). (C.A., 41:5335; S.C.L., 25:157).

Marshall J. scrap chopping machine. Plast. Rubb. wekly 60, 26 Feb. 65, p. 8. Accommodates material 12 x 9".

Mitrovic, L. New Method of reclaiming natural rubber vulcanization which do not contain textiles. Hemiska Industrija, 11: No. 1, pp. 106-07 (1956). (R.A., 35:425). Ground on fluted cracker rolls.

Reclaiming scrap, Plastics (London), 23: p. 366 (1958). (R.A., 36:568). Pelleting scrap.

G. Scott & Son, Ltd. Recovery of rubber from reject tires. Chem. Processing, 5: No. 7, p. 25 (1959). (R.A., 37:515). The tires are put through a prebreaker

Sprout, Waldron & Co., Inc. Monarch ball-bearing attrition mills. (Bulletin). (S.C.L., 21:283). Describing mills used for grinding rubber.

Tugov. I.I. and Il"Ina, E.K. Comminution of the carcass of wornout tires in a frozen condition. Nauchu-Issled. Tr. Vses. Nauc Issled. Inst. Plenochuykh Materialov i Iskusstv. Kozhi. 2: 124-30 (1960): Ref. Zh. Khim., 1963 abstr. 13T428. (R.A. 41:543).

Wendrow, B.R. Production of reclaimed rubber in discrete particle form. U.S. Pat. 2,767,149 (Oct. 16, 1956). (To U.S. Rubber Reclaiming Co.). (C.A., 51:6202; R.A., 35:262). Process of subdividing reclaimed rubber as it comes from a reclaiming apparatus.

Fiber, Rubber, Metals Separation

Allis-Chalmers Mfg. Co. Preliminary metal removal eliminated in new rubber reclaiming process. R.A. (N.Y.), 68: pp. 323-24 (1950). (S.C.L., 29:110).

Amphlett, P.H., Hughes, A.J. and Twiss, D.F. Reclaiming of vulcanized rubber containing cellulose. Brit. Pat. 573,045 (1945). (To Dunlop Rubber Co., Ltd.) (C.A., 43:5992; S.C.L., 24:36). Hydrogen peroxide as an oxidizing agent.

Bailey, E.L. Removal of bonded rubber. U.S. Pat. 2,291862 (Aug. 3, 1942). (C.A., 37:1059; S.C.L., 20:382).

Blow, C.M. Estimation of small percentages of rubber in fibrous materials. I.R.J., 102: pp. 719-22 (Mar. 14, 1942); repr. in Rubber Chem. Tech., 15: pp. 672-77 (1942). (C.A.,36:5381). General discussion.

Boyles, R.M., and Sullivan, D.J. Mechanical separation of fiber in rubber reclaiming. Rubber World, 137: pp. 256-58 (1957). (R.A., 36:87). An illustrated description is given of apparatus used in the main factory of the Midwest Rubber Reclaiming Co.

Broomhead, F. and Priestley, J.J. Debonding of rubber from metal U.S. Pat. 3,034,774 (May 15, 1962). (To W.C. Holmes & Co., Ltd. and Andre Rubber Co., Ltd.) Brit. Pat. 863,846 (29 March 1961).

Butera, G. Removal of fabric in rubber reclamation. Italian Pat. 502,398 (Nov. 29, 1954). (To Pirelli). (C.A., 51:7751; R.A.; 35:425). Autoclaved rubber is comminuted, plunged in alkaline water and the carbonized fabric is removed.

Carr, R.K., and Busenburg, E.B. Reclaiming fiber-reinforced rubber. U.S. Pat., 2,567,802 (Sept. 11, 1951). (To Goodrich). (C.A., 45: 290; S.C.L., 29:1010).

Dasher, P.J. Reclaiming composite material, U.S. Pat. 2,498,398 (Feb. 21, 1950). (To Goodrich). (C.A., 44:3733; S.C.L., 28:399). Mineral acid to degrade the cellulosic fiber.

Dasher, P.J. Removing cellulose fibers from scrap rubber or other acid-resistant material. Brit. Pat. 752,518 (July 11, 1956). (To Dasher Rubber & Chemical Co.). (R.A., 34:509). Scrap with a mineral acid.

Demidov, G.K. Sergeeva N.L. Production of a Fiberous Filler from waste rubberized cord. Kauch i Rezina 25, no. 5, May 66, p 44-6.

Deutsche Asbestwereke George, Reinhold & Co. Recovery of fibrous material from rubber containing products. French Pat. 873,051 (June 29, 1942) (Chem. Zentr. 114: Part II, 1597)

Deutsche Asbestwereke G. Reinhold & Co. Reclaiming fibers from rubberized material containing such fibers. Belg. Pat. 428,780 and Fr. Pat 839,597. (C.A., 33:8448; S.C.L., 17:776). Fibers are removed from scrap tires in machines after swelling, fibers obtained are spun and rubber is powdered.

Dixon, H.L. Separating scrapped vulcanized rubber. U.S. Pat. 2,304,554 (Dec. 8, 1942). (C.A., 37:2960: S.C.L. 21:45). Separating fiber rich portion from rubber rich portion by the difference in the way the scrap pieces bounce.

Dorris, T.B. Fiber-free rubber for reclaim. Rubber Age, 71: pp. 773-80, 821 (1952). (C.A., 46:11748; R.A., 30;528). A process and apparatus are described.

Erygin, E.N. Machine for removing rubber from Reinforcing Elements. Soviet Rubber Technol/Engl. Transl/Vol. 24 No. 3, Page 50 Mar 1965 Len. 3 Lang. Eng.

Fujita, A. Tomihisa, H. and Takamatsu, T. Removing fibers from vulcanized rubber by using cellulose-decomposing enxymes. Japanese Pat. 5,585 (July 26, 1957). (C.A., 52:17780; R.A., 37:192). The product is washed with water and dried.

Gerndt, P.G., and Hannum, J.A. Method of removing rubber from metal. U.S. Pat. 2,406,458 (Aug. 27, 1946). (To U.S. Rubber). (C.A., 41:308; S.C.L., 24:515).

W.C. Holmes & Co., Ltd. De-bonding process. Rubber J., 133: p. 170 (1957). (R.A., 35:509). The Holmes-Andre de-bonding process.

Hughes, A.J., Twiss, D.F., and Dunlop Rubber Co., Ltd. Treating vulcanized rubber containing embedded textile fibrous material. Brit. Pat. 553,674 (June 1, 1943). (C.A., 38:5435; S.C.L., 21:24)

Il'In, N.S. Tugov, I.I. and Arkhangel' sku, N.A. Spinnable fiber from cords from tire covers. I. Nauchn-Issled. Tr. Vses Nauchn-Issled Inst. Plenochnykh Materialov i Iskusstv. Kozhi, 1960 (12): 49-57; Ref. Zh. Khim., 1963: abstr. 14T387. (R.A., 14:543).

Lamb, L. D. Method of separating rubber or rubberlike material from metal. Brit. Pat. 844,500 (Aug. 10, 1960). (To British Oxygen Research & Development, Ltd.). (R.A., 38:641). Use of liquified atmospheric gas.

Lee, J. A. New products from wood. Chem. & Met. Eng., 47: pp. 95-98 (Feb., 1940). Including use of the Masonite gun to "explode" pieces of scrap tires to separate the rubber from the fabric.

Lewis, J. Lewis, S. C., and Rubber Improvement, Ltd. Reclamation of waste rubber. Brit. Pat. 528,196. (S.C.L., 18:845). Separation of canvas from rubber.

Litchfield, L. G. Method and means for stripping thermoplastic sheathing from cables, armored hose and the like. Brit. Pat. 967,377 (Aug. 19, 1964). (To L. B. Plastics, Ltd.). (R.A., 42:622).

Masse, T. J. Separating textile material from rubber. Australian Pat. 111,637 (Sept. 25, 1940). (C.A., 36:3067:S.C.J., 20:323). Passing ground scrap through an electrostatic separator, which retains the fabric threads.

Masse, T.J. Method and apparatus for separating textile material from rubber. U. S. Pat. 2,317,210 (Apr. 20, 1943). (C.A. 37:6160).

Mazzoni, F. Treatment of rubber scrap for reclaim. French Pat. 1,038,502 (Sept. 29, 1953). (R.A., 32:268; Rev. Gen Caout., 31: 206). Separation of cellulose material by aqueous solutions of mineral acids.

Merges H. A. Device for Separation of Rubber and Textile from their Bonded Mixture. B. P. 980698. Separation of rubber and cord and cord by size.

Muraoka Rubber Industry Co. Separation (removing) of fibers in the process for manufacturing reclaimed rubber. Japanese Pat. 4,982/58 (1958). (R.A., 485). Waste rubber is continuously thrown into the gap between two rolls.

North British Rubber co. BP 1034244 Separation of Metal and Rubber. Crumbing, sizing, magnetic separation, sizing.

Osipovskii, B. Y. and Kozlovskaya, A. V. Removal of fibers in reclaiming sodium-bivinyl rubber. Kauchuk i Rezina, No. 10, pp. 43-49 (1940). (C.A., 35:2031:I.R.W., 104:63)

Osipovsky, B. Y. and Volkova, Z.A. Mechanical methods of separating fabric from rubber in reclaiming rubber from tires, Legkaya Prom., 4: No. 4-5 pp. 14-19 (1944). (C.A., 38:6610; S.C.L., 23:153)

Pirelli Societa Per Azioni. Reclaiming rubber from vulcanized rubber. and destroying textile material in vulcanized and unvulcanized rubber scrap. Brit. Pat. 708,788 (May 12, 1954). (R.A., 32:356). Aqueous alkali in an autoclave.

Ray, P.A. Basic Ideas Concerning Flotation in the Removal of Rubber from Paper. Paper Mill, 61: No 51, pp. 13, 18-19 (1938). (Chem. Zent. 110:1:2608; S.C.L., 17:556).

Rubber reclamation aids the plastics industry. Plastics (London) 24: pp 27-28 (1959). (R.A., 37:192). The fiber recovered from waste rubber is more suitable as a filler for thermosetting molding materials than new ground cotton linters.

Seifert, W., and Schindler, H. Felt-like material from corn tire waste. German Pat. 1,001,508 (March 21, 1957). (R.A., 38:263; C.A., 53:22982). Carbon tetrachloride.

Stewart, W. D., Crawford, R. A., and Miller, H. A. Defibering of ground rubber scrap with cellulose-decomposing fungi. Rubber World, 127: pp. 794-96, 801 (1953). (C.A., 47:7810; R.A., 31:274).

Tefft R. F. Treatment of rubber goods. U. S. Pat. 2,321,114 (June 8, 1943) (C.A., 37:6908). Recovering textile material by digesting at elevated temperature with sulfur, a reverting type vulcanization accelerator, and sufficient rubber solvent to dissolve the rubber.

Thiberville, J. Recovery of textiles agglomerated with rubber by separation especially those contained in belting and tires. French Pat. 880,430 (1943). (S.C.L., 24:40).

Thompson, H. H., and Moore, D. V. Method of reclaiming. U. S. Pat. 2,409,402 (Oct. 15, 1946). (To Wingfoot Corp.) (C.A., 41:620; S.C.L. 24:608). A rubber-to-metal bond is disintegrated by exposure to a gaseous mixture of steam and the vapor of a rubber softening oil at 300 to 425°F.

Tokyo Rubber Industry Co. Removing fibers from vulcanized rubber by cellulose-decomposable enzyme. Japanese Pat. 5,585/57 (1957). (C.A., 52:17780; R.A., 36:44).

Trampiron detector. R.A. (N.Y.), 49: pp. 200-01 (1941). (S.C.L., 19:598). For detecting the presence of nails or tacks in sheeted reclaim.

Tugov II. Gorokhouskaya L.L.J. Text. Inst. Abs. 56 #11 Jan. 66 p 779 use of Man Made Fiber Reclaimed from Worn Old Tires. Reclaimed material is blended with wool to make felts and suiting material.

Vil'nitis, S.A., Gel'perin, N. I., Gul', V.E. Kaplunov, Y. N. and Krivopalova, L. P. Method of removing fabric from comminuted rubber-fabric materials. U.S.S.R. Pats. 146,028-9 (Apr. 6, 1962). (R.A., 40:426,436).

Wollfson, B. L. and Chaiko, V. S. Mechanical press for baling textile waste in the reclaim industry. Kauchuk i Rezina, 22 (11): 45-6 (1963); Soviet Rubber Technol. (English Transl.) 22 (11): (1963). (R.A., 42:491).

Future and Potential of Reclaimed Rubber

Alexander, J. W. and Davis, C. L. Process for agglomerating fine rubber particles. Adding oil emulsion to the water slurry containing fines of oil-extended rubber. U. S. Pat. 3,130,160 (Apr. 28, 1964). (To Phillips Petroleum Co.) (C.A., 61:2892,5888).

Dhingra, D. R. and Ghatak, S. N. Utilization of waste vulcanized rubber in industry. Proc. Ann. Convention Oil Tech. Assoc., India, 3: pp. 8-14 9A., 45: 9298; R.A., 30:42).

Dougan, L. D., and Bell, J. C. Synthetic rubber waste disposal. Munic Utilities, 88: No. 9, pp. 62-65, 97-99 (1950). (C.A., 44: 11155; S.C.L., 29:168).

Gutman, A. Problem of Increasing and Improving the Production of Reclaimed Rubber. Kauchuk i Resina, No. 10, pp. 9-13 (1937). (C.A., 32:4380; S.C.L., 16:525).

Howroyd, R. Reclamation of industrial wastes. III. Rubber reclaiming adapts itself to synthetic. Ind. Fibres, Synthetics & By-Products, 7: pp. 330-38 (1945). (C.A., 40:6874; S.C.L., 25:147).

International Rubber Study Group Tokyo May 1964 London 1964, p 50. Review of the present and prospective position of reclaimed rubber.

McCollum, D. L. Reclaimed rubber-past, present, and future. Rubber. Age N. Y. 89 (2), 304 (1961). (R.A., 39:391).

Nourry, A. Reclaimed Rubber. Its development. Application and Future. London: Maclaren & Sons, Ltd. 116 pp. (1962). (R.A., 40: 347)

Placak, O. R. and Ruchhoft, C. C. Study of wastes from the synthetic rubber industry. Sewage Works J., 18: pp. 1169-81 (1946). (C.A., 41: 1869; S.C.L., 25:468).

Stafford, W. E., and Wright, R.A. Recent progress and developments in reclaiming. Rubber Age & Synthetics, 33: pp. 132-35 (1952). (C.A., 46:11749; R.A., 30:278). A Review

Sturtevant Mill Co-Midwest Rubber Reclaiming Co. Reclamation of rubber. Chem. Process (Chicago), 9 (2): 18-9 (1963). (R.A., 41:182). Old tires are used.

History and Review of Reclaimed Rubber

Anon Reviews and Bibliography Kauchuk I. Rezina Vol. 25 No. 9 Page 58 Sept. 1966 Len. 1 Lang. Rus.

Ball, J.M. What is reclaimed rubber and how is it made? (Abstract only). Rubber Age, 83: p.853 (1958). (R.A., 36:506). The leading methods of reclaim are: digestive process, heater or pan process, high pressure steam process and Lancaster-Banbury process.

Ball, J.M. "Reclaimed Rubber–The Story of an American Raw Material". (Book, published, by the Rubber Reclaimers Assn.). (C.A., 41:5747; S.C.L., 25:632; I.R.J., 113:16)

Bostrom, S. Reclaiming of scrap rubber. Gummi-Zig., 54:p.698 (1940). (C.A., 35:1667). Review and discussion of some patents.

Ceresa, R.J. Mechanism of reclaiming. Rubber Plastics Weekly 140 (14), 539-40 (1961). (R.A., 39:345). Mechanical energy, heat and oxygen are the fundamental bases of all reclaiming processes.

Dagaev, P.P. Aqueous dispersions of reclaim. Legkaya Prom., No. 7-8, pp. 21-22 (1944). (C.A., 39:4515; S.C.L., 24:37). Patent literature reviewed.

Elliott, P.M. Reclaims and reclaiming. (Abstract of paper presented at Yale University, April, 1942). Chem. Eng. News, 20:pp. 1223-25, 1252-53 (Oct. 10, 1942). (C.A., 36;7361; S.C.L., 20:411). History of reclaiming.

Esch, W. Reclaim. Gummi-Ztg., 57: pp. 121-22 (1943). (C.A., 38: 6610; S.C.L., 23:150). Review, discussion and development, including notes on methods of analysis.

Forty years of reclaiming at the Pequanoc Rubber Co. I.R.W., 105: No. 1, p. 39 (Oct. 1941).

Hader, R.N. and LeBeau, D.S. Rubber reclaiming. Ind. Eng. Chem. 43: pp. 250-63 (1951). (C.A., 45:3186; S.C.L., 29:290). A review.

Kawaguchi K. Nippon Gomu Kyokaishi, 38, no. 9, (1965) p 755 Recent Situation of Reclaimed Rubber in Japan.

Kilbourne, F.L., Jr. Reclaiming synthetic rubber. R.A. (N.Y.), 64: pp 581-89 (1948). (C.A., 43:3647; S.C.L., 27:57, 346). Review.

Lapadu-Hargues, P. Reclaimed rubber industry in the United States. Rev. Gen. Caout., 25: pp. 16-19 (1948). (C.A., 42:4790; S.C.L., 26: 296). History and economic role.

Lever, A.E. Reclaim – natural and synthetic. I.R.J., 123: pp. 12,14-16 (1952), (C.A. 46:11737; R.A., 30:325). A review.

McRoberts, D.C. Contributors rubber compounding progress: Philadelphia Rubber Works Co. I.R.W., 93:45-7 (Jan. 1936).

Midwest Rubber Reclaiming Co. Reclaiming rubber. Royle Forum, 35:pp. 4-7, 10 (1946). (S.C.L., 24:417). History of reclaiming.

Riemer, Manufacture of reclaim. Gummi Bereifung, 28: No. 1, P. 13 (1952) (R.A., 30:99). Review

Rubber Age – History and Review: Development 50 years – May 1967

Rubber Manufacturers Association, Inc. Summary of data on reclaimed and scrap rubber. (mimeographed bulletin). (S.C.L., 21:45).

Rubber reclaim. Rubber India, 3: No. 9, pp. 15-18; No. 10, pp. 11-14 (1951). (R.A., 30:224). Review.

Sorin G. Facts about Reclaimed Rubber. Chem. Rev. (Japan). 4: pp. 281-90 (1938). (C.A., 32:9559; S.C.L., 17:26).

Stafford, W.E. Utilization of waste rubber. Rubber and Plastics Age 39, 495-8 (1958) The history and uses of ground scrap.

Stafford, W.E., and Sargent D. Present day manufacture and use of reclaimed rubber. Rubber J & Int. Plast. 138: No. 9, p. 310 (1960). (R.A., 38:211). Natural and synthetic.

Stafford, W.E. and Wright, R.A. Modern theories of rubber reclaiming. Proc. Inst. Rubber Ind., 4: pp. 105-14 (1957). (R.A., 35:425). General principles of rubber reclaiming.

Sugimoto, S., and Minakata, T. (IV); Nasu, K. (V) and Endo K. (VIII-XIII). Studies on reclaimed rubber. J. Soc. Rubber Ind., Japan, 14: pp. 509-15, 579-89, 609-21, 621-33, 69007, 761-70, 770-74, 827-35 (1941). (C.A., 42:6151; S.C.L., 26:814). Parts IV through XIII of a series.

Tech. Review 1967 Rubber Age Oct. 1967 p. 51

Thompson, H.H. Manufacture and use of regenerated rubber. (Abstract only). Rubber World, 126: p. 387 (1952). (R.A., 30:365). Review.

Wolf, R. Old Tires Don't Fade Away Rubber Age/NY/Vol. 100 No. 2 Page 68 Feb. 1968 Len. 6 Lang. Eng.

Wolf, H.P. Story of scrap rubber. (Book). (C.A., 38:1914) Relates the history of scrap rubber. Schulman (Printer)

Wendrow, B.R. Reclaimed rubber-its place in the rubber industry (Abstract only). Rubber World, 140: pp. 275-76 (1959). (R.A., 37:375). The early history of the reclaimed rubber industry.

Methods/Processing of Reclaimed Rubber

Alexander, P.I. Solution process of rubber reclaiming. German Pat. 705,363. (C.A., 36:2447; S.C.L. 20; 215; Chem. Sentr. 112: Part II, 824).

Amphlett, P.H., Hughes, A.J., Twiss, D.F., and Dunlop Rubber Co., Ltd. Regeneration of synthetic rubberlike materials and utilization of this regenerated material. Brit. Pat. 564,514 (Oct. 2, 1944). (To Dunlop). (C.A., 40:3640; S.C.L., 22:393). Reclaiming of polymers of butadiene alone or with styrene or acrylonitrile by subjecting to mechanical working with or without a softener.

Augenstein, J.G. and Sverdrup, E. New Reclaiming Process. (Abstracts only). R.A. (N.Y.), 65: p. 63 (1949); I.R.W., 120: p. 92 (1949) (S.C.L., 27:511) Dip reclaiming.

Ball, J.M. and Randall, R.L. Reclaimed rubber during reconversion I.R.W., 114: pp. 368-73 (1946). (C.A., 40:5950; S.C.L., 24:461). See also Can. Chem. Process Ind., 30: pp. 24-28, 93 (1946). (C.A., 40:5286).

Banbury, F.H., Comes, D.A., and Schnuck, C.F. Reclaiming scrap vulcanized rubber. U.S. Pats. 2,461,192 and 2,461,193 (Feb. 8, 1949) (To Lancaster Processes, Inc.). (S.C.L., 27:686).

Barabonoy, P.P. Reclaiming synthetic rubber by the thermal swelling method Kauchuk i Resina, No. 10: pp. 70-72 (1939). (C.A., 36:2756; S.C.L., 20:316).

Barbanov, P., and Leonovich, V. The acid Alkali method of reclaiming scrap rubber. J. Rub. Ind. (U.S.S.R.), 12:1048-50 (1935). (C.A., 30:6981).

Bata Narodni Podnik, Regeneration of natural or synthetic rubber. Brit. Pat. Appl. 18,539/47 (Aug. 6, 1953). (R.A., 31:455). Mechanical homogenization in a closed space.

Bemelmans, E. Conversion of old tires with their entire constitutents into plastic material. "Recueil des Communications-Congres International due Caoutchouc" Repr. in G.Z., 51: pp. 917-18 (1937); LeCaout., 34: pp. 258-59, 289 (1937). Abst. in R.A. (N.Y.), 41: No. 5, p. 313 (Aug. 1937) (S.C.L., 15:460 and 682).

Beverly J.A. USP 3318838 Reclaiming and Treating Synthetic Rubbers. Scrap is heated in reclaiming oils to 420° to drive off water and soften particle for use.

Bielenky, X.I. Technical reclaiming of a combination of natural and synthetic rubbers. J. Rub. Ind. (U.S.S.R.), 12:68-74 (1935); Rev. Gen. Caout., p. 29, July-Aug. 1936, (S.C.L., 14:674).

Bishop, C.E. Bisho process for the reclaiming of rubber. R.A. (N.Y.) 50: p 116 (Nov. 1941).

Coinon, H., and Laboratorire de Rechereches et de Controle du Caoutchouc et de L'aminate. Reclaiming synthetic and natural rubber waste. French Pat. 932,038. (S.C.L., 27: 689; Rev. Gen. Caout, 26:531).

Comes, D., and Banbury, F.H. Lancaster-Banbury method of devulcanizing scrap rubber. R.A. (N.Y.), 59: pp. 563-66 (1946). (C.A., 40:5950; S.C.L., 24:561).

Compagnie Generale de Telegraphie Sans Fil. Electostatic reclaiming of rubber by high frequency fields. French Pat. 921,441 (1948). (S.C.L., 26:547; Rev. Gen. Caout., 25:46).

Convert, L. Reclaiming rubber by recent processes. Rev. Gen. Cauot., 19: pp. 58-60 (1942). S.C.L., 23:305).

Cotton, F.H., and Gibbons, P.A. Process of reclaiming rubber. U.S. Pat. 2,408,296 (Sept. 24, 1946). (C.A., 41:619) See also Brit. Pats. 577,829 and 577,830 (1946). (S.C.L., 24:418,423).

Davis, R.C. Reclaiming of vulcanized rubber. Brit. Pat. 573,053 (1945). (To Dunlop Rubber Co., Ltd.). (C.A., 43:4892; S.C.L., 24:36). Powdered and heated.

Dasher, P.J., and Summit Industrial Products Co. Develop new reclaiming process. R.A. (N.Y.). 60: p. 564 (1947). (S.C.L., 25:418).

Dasher, P.J. Method of treating waste latex from U.S. Pat. 2814-075 (Nov. 26, 1957). (To Dasher Rubber & Chemical Co.). (C.A., 52:4232; R.A., 36:254). The process aims at eliminating the drying step.

Dasher, P.J. Methods for reclaiming unvulcanized rubber scrap or the like; containing fiber, by treatment with mineral acid vapor. U.S. Pat. 2,701,268 (Feb. 1, 1955). (To Dasher Rubber & Chemical Co.). (C.A., 49:8628; R.A., 33:344).

Dasher, P.J. Process of reclaiming scrap vulcanized rubber. U.S. Pat. 2,966,468 (Dec. 27, 1960). (To Dasher Rubber & Chemical Co.). (R.A., 39:346) Reclaimed defibered tires.

Dasher, P.J. Apparatus for reclaiming unvulcanized rubber scrap, or the like containing fiber. U.S. Pat. 2,927,342 (March 8, 1960). (To Dasher Rubber & Chemical Co.). (R.A., 38:537; C.A., 54:1829). Scrap subjected to hydrochloric acid.

Dasher, P.J. Process of reclaiming scrap vulcanized rubber. Brit. Pat. 871,925 (July 5, 1961). (To Dasher Rubber & Chemical Co.). (C.A., 55:26502; R.A., 39:533). Grinding in a Banbury.

DeBecker, R. Grinding and reclaiming of vulcanized rubber. Belgian Pats. 455,756 and 455,757 (1947). (S.C.L., 25:417; Rev. Gen. Caout., 24:8).

Dogadkin, B., Koshelev, F., and Tartakowski I. Regeneration of rubber according to the dispersion method, J. Rub. Ind. (U.S.S.R.) pp. 941-44 (Aug.-Sept. 1936). (Chem. Zent., 108 I:1300).

Dogadkin, B.A., Zachesova, G.N. and Shokhin, I.A. Reclaiming rubber in the form of aqueous dispersions. Kauchuk i Rezina, 20 (12): 15-21 (1961); Soviet Rubber Technol. 20 (12); 15-21 (1961). (C.A., 57:1006; R.A., 41:20). Quality of reclaim is improved by peptizers.

Drozdovskii, V.F. Shokhin, I.A. and Bairova, E.D. Breakdown of monosulfide bonds in vulcanizates. Soviet Rubber Technol. (English Transl.) 22(7); 36-7 (1963). (C.A., 59:12997).

Dufour, R., and Leduc, H.A. Method and apparatus for heating in particular for pre-vulcanizing, or reclaiming rubber mixes or similar materials. German Pat. 948,557 (Aug. 16, 1956). (R.A., 35:368). Fillers and additives.

Elgin, J.C. and Sverdrup, E.F. Extrusion apparatus utilizable for reclaimed rubber. U.S. Pats. 2,653,348 and 2,653,349 (Sept. 29, 1953). (To U.S. Rubber Reclaiming Co., Inc.). (R.A., 32:347).

Esch, W. Reclaiming waste rubber. Seifen-Ole-Pette-Wachse, 75: pp. 168-70, 189-90, 209-10 (1949). (C.A., 44:1275; S.C.L., 28:215).

Esch, W. Processes for rubber reclaiming. Seifen-Ole-Pette-Washse, 75: pp. 189-90, 209-10 (1949). (C.A., 44:1275; S.C.L., 28:398).

Fabritziev, B. Reclaiming of rubber. J. Rub. Ind. (U.S.S.R.). 427-31,539 (1936). (C.A., 30:7383, S.C.L., 14:374).

Fabritziev, B. and Korschunov, D. Reclaiming of Rubber from Old Galoshes and Rubbers made of Mixtures of Synthetic and Natural Rubber. Kauchuk i Rezina No. 7-8, pp. 60-62 (1937) (C.A., 32:2781).

Federman, A.G. Process of degrading rubber by heat. U.S. Pat. 2,287,095 (June 23, 1942) (C.A., 37:284; S.C.L., 20:318).

Fickers, Stieler A. New Method of Reclaiming Scrap Rubber. Rubber Age, 95, 6 Sept. 64, p. 890. Mechanical crushing, electrostatic separation air table.

Frazer, H.B. Comparison of reclaiming processes with a note on a new thermal process. Trans. Inst. Rubber Ind., 19:pp. 180-190 (1944). (C.A., 38:3873). Describes an experimental plant for thermal reclaim.

Freiman, P.E. Reclaiming synthetic rubber galoshes by the acid method. Kauchuk i Rezina, No. 4-5, pp. 77-78 (1940). (C.A., 34:7658). Data on reclaiming all synthetic galoshes.

Gallois, L. Reclaiming rubber and the like. French Pat. 976,713 (Mar. 21, 1951). (S.C.L., 29:928; Rev. Gen. Caout, 28:667).

Ghez, H. and Ghez O. Regeneration of rubber. Netherlands Pat. 54,671. (S.C.L., 23:270; Rev. Gen. Caout., 20:78). Vulcanized rubber is heated in a bath of a substance which is good conductor of heat during mastication this material functions as a plasticizer.

Ghez, H. and Ghez, O. Rubber reclaiming. Can. Pat. 408,751 (Nov. 17, 1942) Nervastral process.

Ghez, H., and Ghez, O. Reclaiming rubber. Belg. Pat. 434,136 (S.C.L., 18:180) Heating scrap, without grinding, with a softening agent until plasticization is obtainable on rolls.

Glass, G.J. and Bruggemeier, G.L. Reclaim processing apparatus. U.S. Pat. 2,730,759 (Jan. 17, 1956). (To Firestone). (R.A., 34,422). Extrusion type device.

Glazunov, G.I. The reclaiming of synthetic rubber by the solution method. J. Rub. Ind. (U.S.S.R.), 12:910-15 (1935). (C.A., 30:5454: S.C.L., 14:580).

Green, J. Processes for reclaiming vulcanized natural and/or synthetic rubber and for producing reaction products therefrom. Brit. Pat. 828,162 (Feb. 17, 1960). (To U.S. Rubber Reclaiming Co.). (R.A., 38:275; C.A., 54:11539). An oil may be included.

Gunzert, T., Renneman, H., and Continental Gummi-Werke A.-G. Reclaiming vulcanized scrap from Synthetic rubber. German Pats. 716,149 and 716,151. (C.A., 38:2524; S.C.L., 21:77 Gummi- Ztg. 56:129).

Haehl, A. Investigation on the plasticization of reclaim. Rev. Gen. Caout., 20: p. 3 (1943). (C.A., 38:5112; S.C.L., 22:133).

Hensley, W.A., and Albert, H.E. Reclaiming rubbers. U.S.Pat. 2,686,162 (Aug. 10, 1954). (To Firestone). (R.A., 33:73) Reclaimed by heating.

Heyman, J. New Thermo-chemical method of reclaiming. LaGoma p.7 June 1936 (S.C.L., 15:157).

Hirschberger, J. Apparatus for reclaiming or regenerating rubber from rubber waste products. U.S. Pat. 2,311,836 (Oct. 12, 1943). (C.A., 38:1916).

Hyde, W.J. Methods and apparatus for reclaiming cable sheaths U.S. Pat. 2,894,868 (July 14, 1959). (To Western Electric). (R.A., 38:51).

I.G. Farbenindustrie, A.-G. Reclaiming rubber vulcanizates. Belgian Pat. 453,049 (1947). (S.C.L., 25:417; Rev. Gen. Caout., 24:8).

Imperial Chemical Industries Ltd. Reclaiming of foamed latex scrap. (Technical Information Rubber 9, 1954). (R.A., 32:443).

Johnston, A. Regeneration of waste rubber. U.S. Pat. 2,404,293 (July 16, 1946). (C.A., 40:6290). See also U.S. Pat. 2,406,297 (Aug. 20, 1946). (C.A., 41:310).

Karthaus, H. Method and apparatus for reclaiming of rubber. German Pat. 861,748 (Nov. 13, 1952). (To Continental Gummi Works, A.-G.). (R.A., 31:507).

Keleti, Z., and Wolfner Gyula Estarsa Gumigyar, R.T. Reclaiming vulcanized rubber. Hungarian Pat. 135,618. (C.A., 44:6192; S.C.L., 28:710). Heated by a bath of an alloy metal.

Keleti, Z. Method and device for reclaiming rubber waste Hung. Pat. 137,376 (Oct. 31, 1962); Ref. Zh. Khim., 1964: abstr. 7S464P. (R.A., 42:384).

Khan, A.A., Majumdar, B.C., and Siddiquit, S. Depolymerization of rubber. Indian Pat. 34,938. (C.A., 44:6670; S.C.L. 28:773).

Kilbourne, F.L. Synthetic rubber reclaiming method. Can. Pat. 424,229 (Dec. 5, 1944). (To Firestone). Heating a mixture of a swelling agent, a softening agent and a vulcanized synthetic rubber of the type of neoprene, Buna S. or Buna N.

Kirby, W.G. Rubber reclaiming process. Can. Pat. 403,630 (Mar. 24, 1942) (To U.S. Rubber). (C.A., 36:3984). Same as U.S. Pat. 2,276,248.

Kirby, W.G. and Steinle, L.E. Reclaimation of rubber. U.S. Pat. 2,279,047 (April 7, 1942). (To U.S. Rubber). (C.A., 36:6376). In one operation by the combined action of air, heat, alkali and rubber softener.

Kluckow, P. Means of renovating rubber products and materials for sealing hose. Kautschuk, 18: pp. 142-43 (1942). (C.A., 39:2004: S.C.L., 23:308). For old tires and rubber rolls which would otherwise become scrap rubber.

Knowland, T.M. Preparing rubber for reclaiming. U.S. Pat. 2,462,645 (Feb. 22, 1949). (To Boston Woven Hose & Rubber Co.). (C.A., 43:4046; S.C.L., 27:356).

Krobel, F. Regenerating old rubber. Ger. Pat. 701,913 (Dec. 24, 1940). (C.A., 36:296).

Laboratorire de la Societe Anonyme des Matieres Colorants de Saint-Denis and l'Institut Francais due Caoutchouc. Processing of reclaimed rubber and the effects of small proportions of new rubber in a reclaimed-rubber mixture. Gummi-Ztg., 56: pp. 27-28, 39-41, 51 (1943). (C.A., 37:6493). Report of investigation of reclaimed rubbers made by the alkali process and by heat plasticization.

LeBeau, D.S. Reclaiming process for synthetic rubber. I.R.W., 106: p.599 (1942). (S.C.L., 20:410).

LeBeau, R.V. Rubber reclaims. U.S. Pat. 2,783,213 (Feb. 26, 1957). (To Midwest Rubber Reclaiming Co.). (C.A., 51:12533; R.A. 35:533). The process is applicable to both natural and synthetic rubber.

Lebedey, P.D. Autoclave for reclaiming rubber by the solution method Kauchuk i Rezina, No. 6: pp. 62-64 (1940). (S.C.L., 24:433).

LeBras, J., and Haehl, A. Preparation of reclaim. Rev. Gen. Caout., 18:pp. 51-53 (1941). (S.C.L., 20:185; Chem. Zentr., 113:i,546).

Lemercier, A. Depolymerization breakdown and reclaiming of natural or synthetic rubber, crude or vulcanized. French Pat. 906,544 (1947). (To Societe Electro-Cable).(S.C.L., 25:417; Rev. Gen. Caout., 24:8).

Lemercier, A., and Societe Electro-Cable. Process for the depolymerization rubber and for regeneration. Brit. Pat. 622-914.

Lewis, J. and Lewis, S.C. Reclaiming rubber. Brit. Pat. 582,568, addition to Brit. Pat. 569,659 (1945). (C.A., 41:6074; S.C.L., 25:147).

Lewis, J. Processing or reclaim Trans. Inst. Rubber Ind. 17: pp. 27275 (Feb., 1942). (C.A., 36:6046).

Litvinenko, A.G. Dyunnina, V.G. and Tugov, I.I. Automation of mix preparation. I. Preparation of rubbers and reclaim for mixing Nauchin, Issled. Tr., Vses. Nauchn. Issled. Inst. Plenochnykh Materialov i Iskusstv. Kozhi, 10: 67-74 (1959); Ref. Sh. Khim 1964; abstr. 9S535. (R.A., 42:548).

Maruyama, T. Regenerating waste rubber. Japan Ind. News; I.R.J., 91:751 (1936). (S.C.L., 14:387).

Marzetti, G.B. Rubber Wastes Reclaiming. Italian Pat. 425,884. (C.A., 43:4892; S.C.L., 27:784).

Maurin, A. Process for reclaiming rubber. French Pat. 1,237,993 (Sept. 9, 1959); Rev. Gen. Caoutchouc 38 (4). abstr. 627 (1961). (C.A., 55:15984; R.A. 39:487). For natural or synthetic vulcanizates.

McCowan, W.A., and Twiss, D.F. Reclaiming vulcanized synthetic rubberlike material. Brit. Pat. 580,051 (1946). (To Dunlop Rubber Co.) (S.C.L. 24:550) (Mechanical Method).

Mellersh-Jackson, L., Jr. Reclaiming rubber or rubber scrap containing synthetic rubber. Brit. Pat. 584,667 (1947). (S.C.L., 25:331). See also Brit. Pat. 587,031. (S.C.L., 25:552).

Menadue, F.B. Rubber reclaim, I.R.J. 106: pp. 546, 548-49 (1944). (C.A., 39:1077; S.C.L., 23:71). Review of current reclaiming processes from the point of view of their efficiency in conserving the properties of the rubber.

Michelen & Cie BP 1032011 Regenerating Rubber of a Kind Vulcanisable by Sulfur. Subdivide the rubber, swell in solvent, heat to devulcanize & dissolve rubber in solvent.

Mishustin, I.U. Reclaiming black synthetic rubber. Kozhevenno-Obuvnaya Prom., 19: No. 7, pp. 29-31 (1940). (C.A., 35:5347).

Montecatini Soc. Gen. F.P. 1429092 Regeneration of Elastomers based saturated vulcanized olefin copolymers. Polymers heated to 175-225°C, 2-10 hours.

Navone, J.O. Reclaiming rubber. U.S. Pat. 2,487,666 (Nov. 8, 1949) (S.C.L. 28:215). Process.

Nervastral Rubber reclaiming processes, R.A. (N.Y.) 50: p. 359 (Feb. 1942). (C.A., 36:6047).

Newton, R.G. and Scott, J.R. (1) Reduction of rubber content of mixings. (II) Use of crumb rubber and simple reclaiming processes. R.A. (London). 27: pp. 268, 270,273,302, (1946). (C.A., 40:7687; S.C.L., 25:336,337).

Nippon Rubber Co. Continuous high speed devulcanizing method. Japan Pat. 5378 (1960). (R.A., 40:37). Comminuted waste rubber is fed to a screw extruder where the heat generated causes devulcanization.

Obloczynski, J. Reclaiming of vulcanized synthetic rubber scrap. Brit. Pat. 581,589 (1946). (To North British Rubber Co., Ltd.).

Oishi, Y. Apparatus for reclaiming rubber material. U.S. Pats. 2,786,635-36 (March 26, 1957). (To Muraoka Rub-Reclaiming Co.). (R.A., 35:629). U.S. Pat. 2,686,011 (Aug. 10, 1954) (R.A., 33:93).

Ossipovskii, B.J. Wergiless, F.A. and Manontov, B.W. Rubber Reclaiming by the Solvent Process of Glasunov and Ptitzyn, Kauchuk i Rezina, No. 11 pp. 54-63 (1948). (C.A., 33:4457); (Chem Zent., 110:I:4541; S.C.L., 17:445). Plants using the solution method. Kauchuk i Rezina, No. 4: pp. 42-46 (1941) (C.A., 37:5621).

Ownes, EWB. Processes of reclaiming rubber and their relative merits. Trans. Inst. Rubber Ind. 19: pp. 111-120 (Oct. 1943). (C.A., 38:1910, 5687). Repr. in Rubber Chem. Tech., 17:pp. 544-50 (1944).

Palmer, H.F., and Hines, J.M. Automatic proportioning and blending of liquid chemicals in a reclaimed rubber plant. Trans. Am. Inst. Chem. Engrs., 36: pp. 233-44 (1940). (C.A., 34-4609).

Panoulleres, G. Bemelman's process for the regeneration of old rubber LeCaout., 33:17468-9 (Mar. 15, 1936); 28 line abst. in R.A. (London), 17:219 (1936). (S.C.L., 14:243).

Patentverwertungs, G.m.b.H. "Hermes". Reclaiming synthetic rubber. French Pat. 888,587. (S.C.L., 23:414; Rev. Gen. Caout., 20:94).

Peterson, C.H. Reclaimed rubber U.S. Pat. 2,804,651 (Sept. 3, 1957). (To U.S. Rubber Reclaiming Co.). (R.A., 36:160). Working comminuted vulcanized rubber while progressively forcing it forward through an elongated chamber.

Pluhacek, R., and Svit, Narodni Podnik Reclaiming process. Swedish Pat. 120,053 (Sept. 7, 1950). (S.C.L., 29:568).

Plumart de Rieux, W.F., and Devorsine, M.J.P.M. Improved process for reclaiming rubber. French Pat. 1,191,633 (Oct. 21, 1959). (Rev. Gen. Caout., 37:466; R.A. 38:422). Continuous process.

Reclamation of rubber scrap. Chem. Age (London), 46: p. 206 (1942). (S.C.L., 20:185).

Reclaiming of S.K. Kauchuk i Rezina, No. 11; pp. 63-73 (1938). (I.R.W., 109:47).

Reclaiming processes for rubber. Oil, Paint & Drug Reptr., 143:No. 24, p. 62 (June 14, 1943).

Reclaiming rubber. Elec. Review (London), 130: pp. 551-54 (1942) (S.C.L. 120:214).

Reiner, S. Reclaiming Synthetic Vulcanized Rubber. German Pat. 749,745 (1947). (S.C.L., 25:915).

Rennemann, H., and Gunzert, T. Regenerating vulcanized synthetic rubber scrap by the alkali process. German Pat. 716,150 (Dec. 11, 1941). (C.A., 38:2524).

Rimpel, H. Regeneration of rubber waste in the light of modern research. Medd. Sveriges Kem. Ind., 24: pp. 73-83 (1941). (C.A., 36:682).

Ritchie, J.H. and Levinovitsch, L. Treatment of Vulcanized rubber. Brit. Pat. 561,262 (May 11, 1944). (C.A., 39:5124). Reclaiming process.

Robinson, T. Reclaimed rubber and method of producing it. U.S. Pat. 2,221,490 (Nov. 12, 1940). Reducing scrap to a mass of relatively small pieces and subjecting them to mechanical action in an internal mixer at an elevated temperature.

Rostler, F., and Mehner, V. Rubber reclaiming. U.S. Pat. 2,244,654 (June 3, 1941). Treating scrap by heating it with a water solution of caustic alkali and rubber miscible oil of viscous unsaturated hydrocarbons.

Rozhdestverskii, S.I. Reclaiming of tires by the alkali method. Kauchuk i Rezina, No. 4-5, pp. 74-75 (1940). (C.A., 34:7659). Containing synthetic rubber.

Rubber & Plastics Compound Co., Inc. Nervastral rubber reclaiming processes (Booklet). Reviewed in R.A. (N.Y.), 50:p. 359 (1942) (S.C.L., 20:214).

Rubber reclaiming. Chem. & Met. Eng., 48:pp. 112-15 (June, 1941). Description of the alkali process used by Goodyear.

Schenck, E.L. Reclaiming tires. U.S. Pat. 2,471,043 (May 24, 1949). (S.C.L. 27:719).

Selivanova, A.I. Reclaiming of Rubber from Synthetic Rubber (A review of suggested procedures). Kauchuk i Rezina, No. 11, pp. 63-72 (1938). (C.A., 33:4457; S.C.L., 17:445).

Shokhin, I.A., and Tikhonovich, L.V. Investigation of the technological properties of reclaim. Trudy Nauch Issledovatel. Inst. Rezin Prom., No. 2, pp.146-64 (1955). (R.A., 34:533). The authors recommend mastication by stages.

Singleton, R. Reclaim manufacture by the Reclaimator process Rubber J., 146 (2): 46-8, 50 (1964). (R.A., 41:171). Flow sheets are given.

Societe Anon. Des Penumatiques Dunlop. Reclaiming synthetic rubbers. French Pat. 936,519 (S.C.L., 27:154; Rev. Gen. Caout., 25:126). Process.

Societe Industriele du Caoutchouc and L'Eplattenier, G. Reclaiming vulcanized rubber. French Pat. 919,385 (1948). (C.A., 43:4510; S.C.L., 26:296; Rev. Gen. Caout, 25:11). High frequency alternating electric field.

Societa Italiana Pirelli, Regeneration of vulcanized rubber. Brit. Pat. 535,531. (S.C.L., 19:394). Swelling the rubber to the point of dissolution, heating in the presence of a devulcanizing agent under superatmospheric pressure, removing the agent and products of devulcanization, and washing to remove the solvent or swelling agent.

Societa Italiana Pirelli, Reclaiming old rubber by the alkali method German Pat. 726,640. (C.A., 37:6496; S.C.L., 21:239; Kautschuk, 19:46).

Sorochenko, A.F. Rudskoi, R.B. Gaivoronskaya, R.I. Polozov, G.K. Profof'ev, V.I. Zinevich, A.M. and Groumov, E.N. Twin screw mixer for preparing reclaim and rubber compounds. USSR Pat. 149,557, (July 9, 1962); Byul, Izobret. 39 (16), 45 (1962). (R.A., 40:620).

Stafford, W.E., Armstead, B.H. Proc. Inst. Rubber Ind. 12,208 (1965) Reclaiming Conditions giving greatest property divergence for SBR or NR reclaim.

Stafford, Reclaim Syn Elastomers Vol. 40, No. 4, Page T163, Year 1964 Line 13 Trans. IRI.

Stafford, W.E. Some aspects of the reclaiming of synthetic elastomers. Inst. Rubber Ind. Trans., 40 (4): 163-75 (1964).

Stefan Ficker & Alfred Stieler A New Method of Reclaiming Scrap Rubber, Rubber Age Sept. 1964 p. 890.

Sverdrup, E.F. Rubber reclaiming apparatus. U.S. Pat. 2,633,602 (Apr. 7, 1953). (To U.S. Rubber Reclaiming Co., Inc.). (R.A., 31:541). Extrusion apparatus.

Svetajeva, J.M. Reclaiming synthetic rubber by the thermal swelling method. Abstract only in Chem. Zentr. 111: Part II, 2398. (Kautschuk, 17:42; S.C.L., 21:144).

Tandy, W.A. and Woods, F. Technology of reclaim. Indian Rubber Bull. 1963 (172): 26-30, (173): 24-31. (R.A., 41:453).

Thermodynamic reclaim: Energy absorption fundamental to new process I.R.J. 105: p. 339 (Oct. 2, 1943).

Treiman, O.A. Reclaiming synthetic rubber galoshes by the acid method. Kauchuk i Rezina, No. 4-5, pp. 70-74 (1940). (C.A., 34:7658). See Reference NR-6.

Treves, A. Reclaiming vulcanized rubber. French Pat. 866,799. (S.C.L., 23:463 Rev. Gen. Caout., 18:288).

Triska E. Rubber Trade Enterprises Ltd., London 1967 p. 75. A detailed presentation of the Palma process.

Tsvetaeva, E.M. Drugovskaya, M.N. Svereva, N.I. Kolkhir, K.F. and Lobenovich V.A. Method of reclaiming vulcanized rubber. (C.A., 57:6094; R.A., 40:236).

Tsvetaeva, E.M. Reclaiming synthetic rubber by thermal swelling Kauchuk i Rezina, No. 4-5, pp. 67-70 (1940). (C.A., 34:7658).

Tsvetaeva, E.M. Influence of the bath and the method of thermal treatment on the reclaiming of SKB rubber. Legkaya Prom., 4:p. 20 (1944). (C.A., 39:5542; S.C.L., 24:67).

Tuckett, R.F. Degradation of high polymers. Trans. Faraday Soc., 41: pp. 351-59 (July, 1945). (C.A., 39:5164).

United Reclaim, Ltd. and Dunlop Rubber Co. Ltd. Reclaim plant. Rubber Plastics Age, 44 (12): 1522-3 (1963); Ind. Chemist, 40 (1): 49 (1964); Rubber Develop., 16 (4): 128-9 (1963) (R.A., 42:115).

United States Rubber Co. Reclamation of rubber. Brit. Pat. 522,183. (B.C.A. (B) 631-1940). Producing cellulose-type reclaimed rubber by mixing fiber-containing rubber stock with a solution of sale, and treating.

United States Rubber Co. Method of reclaiming rubber. Brit. Pat. 965,177 (July 29, 1964) (R.A., 42:545).

United States Rubber Co. Reclaiming mixtures of vulcanized natural rubber and synthetic rubber scrap. Brit. Pat. 687,054 (Feb. 4, 1953). (R.A., 31:227).

United States Rubber Co. Reclaiming waste polychloroprenes. Brit. Pat. 557,803 (Dec. 15, 1943). (C.A., 39:3462; S.C.L., 22:14).

United States Rubber Co. Reclaiming of vulcanized scrap natural and or synthetic rubber. Brit. Pat. 747,997 (April 18, 1956). (R.A., 34:332).

U.S. Rubber Reclaiming Co. Rubber reclaiming apparatus. Brit. Pat. 902,943 (Aug. 9, 1962). (R.A., 40:577).

United States Rubber Reclaiming Co., Inc. Extrusion apparatus for use in reclaiming rubber. Brit. Pat. 729,825 (May 11, 1955). (R.A., 33:381). A screw rotating in a cylindrical casing.

U.S. Rubber Reclaiming Co., Inc. Method for reclaiming rubber British Pat. 610,812 (S.C.L., 27:158).

Usines Mongroises de Caoutchouc, Plasticizing products made from vulcanized synthetic rubber. French Pat. 889,384. (S.C.L., 23:234; Rev. Gen. Caout., 21:42). Reclaiming method.

Van Amerongen, G.J. Depolymerizing by heat. Netherlands Pat. 63,006. (To Rubber Stichting). (C.A., 43:5231; S.C.L., 27:742).

Vinitskii, L.E. Use of seeding in the preparation of reclaim mixes. Kauchuk i Rezina, 16: No. 9, pp. 33-34 (1957). (C.A., 52:10627; R.A., 36:160).

Watson, W.F. Degradation of natural rubber in a solution in vacuo. Trans. Inst. Rubber Ind., 29: pp. 202-14 (1953); repr. in Rubber Chem. Tech. 26: pp. 798-809 (1953). (C.A., 48:8572; R.A. 31,453). Degrades in the absence of oxygen.

Wettly, J. New Technique for reclaiming: The "dip process", Rev. Gen. Caout. 29: pp. 192-94, 206 (1952). (C.A., 46:4837; R.A., 30:176).

Weydert, L. Reclaiming rubber by use of high pressure and material for use in process. Addition No. 51,693 to French Pat. 872,614 (1944), (S.C.L., 24:37; Rev. Gen. Caout., 21:11).

White, C.M. Oxidized tall oil and petroleum oil composition method of making and method of reclaiming rubber. U.S. Pat. 3,043,786 (July 10, 1962). (C.A., 57:10015; R.A., 41:107). A small amount (0.5 to 2.5% by weight) of tall oil oxidized as described is added to rubber being reclaimed. An example describes the reclamation of SBR.

Zachesova, G.N., Dogadkin, B.A., and Shokhin, A.I. Method of reclaim of vulcanized rubber by dispersion. Russian Pat. 127,382 (March 25, 1960). (R.A., 38:328; C.A., 54:19004).

Zemek, J. and Lukovsky, L. Method of treating unvulcanized waste formed in the production of cellular rubber. Czech. Pat. 103,971 (June 15, 1962): Ref. Zh. Khim., 1964: abstr. 3S673P. (R.A., 42:224).

Zielinski W. Properties and use of reclaim obtained by Radiation. Ref. Zh. Khim 1965 abs 12S563 P Magyar kem lapja 19.6 (1964) p. 300. Rubber waste processed with Co radiation, loss in tensile.

Miscellaneous

Abons, G. Distillation of the Solvent in the Reclaiming of Rubber by the Solvent Method. Kauchuk i Rezina, No. 1, pp. 36-48 (1937). (C.A., 32:4003; S.C.L., 16:525).

Ball, J.M., and Randall, R.L. Rate of cure of present day while tire reclaimed rubber. I.R.W., 124: pp. 53-57, 66 (1951). (C.A., 45:6420; S.C.L., 29:290,568; R.A., 68:565).

Dzottsoi, S.K. Investigation of the influence of reclaim on the working properties of synthetic sodium butadiene vulcanizates SB. tr. Azerb. Med. Inst., 4: pp. 324-28 (1958). (R.A., 38:222).

Galan, R.R. Reclaimed rubbers. Rev. Plasticos Mod. (Madrid), 14 (90): 1018-22 (1963); 15 (92): 134-8 (1964). (R.A., 42:447).

Haehl, A. Mixing factors and their influence, III. Role of reclaim Rev. Gen. Caout., 22: pp. 78-81 (1945). (C.A., 40:6874; S.C.L., 24:62).

Kochis, P.E. Process for dispersing reclaimed silicone rubber in a silicone gum, U.S. Pat. 3,063,975 (Nov. 13, 1962). (To Dupont). (C.A., 58:4714; R.A., 41:329).

Mankowich, I. Chiavetta, F.P. and Charter, R.A. Polymerization of monoolefins in the presence of comminuted reclaim. U.S. Pat. 3,042,634 (July 3, 1962). (C.A., 57:10036; R.A., 41:107).

Stafford, W.E. Aging of reclaim. Trans. Inst. Rubber Ind. 17:pp 264-67 (Feb. 1942). (C.A., 36:5675).

Stafford, W.E. and Sargent, D.T. Some considerations of reclaiming mechanisms. Rubber J. Int. Plast., 136: pp. 5-6, 39-40 (1959). (R.A., 37:112). The modern aspects of reclaiming are discussed.

Stafford, W.E., Wright, R.A., and Sargent, D. Contribution of the mechanism of devulcanization. Rubber J. 130: pp. 292, 294-96 (1956); Rubber & Plastics Age, 37: pp. 87-92

(1957). (C.A., 50:9778; R.A., 34:236,383). Work is recorded on the behavior of three types of vulcanizates.

Totsch, C.H. Rubber Age, 97, no. 6, Sept. 1965, p. 79 Reclaimed Rubber in Bale Form. Advantage and disadvantages are discussed.

Zaionchkovskii, A.D., and Livyi, G.V. Destruction of rubber materials in reclaim manufacture. Legkaya Prom., No. 9, p. 34 (1955). (C.A., 50: 22; R.A., 34:279). Destruction is accelerated by oxidants.

Properties of Reclaimed Rubber

Babitskii, B.L. and Vinitskii, L.E. Certain features of the structure of filled vulcanizates based on reclaim vol. 25, no. 6, p 21 (1966) Sov. Rubb. Tech.

Babitskii, B.L. Vinitskii, L.E. and Kaplunov, Ya. N. Electrically insulating rubbers based on reclaim. Vestin. Tekhn. Ekon INform. Nauchn. Inst. Tekhn.-Ekon. Issled. Gas. Komiteta i Neft. Prom. PRI Gosplane SSSR, 1963 (3): 38-9; Ref. Zh Khim. 1964; Abstr. 4S389. (R.A., 42:279).

Babitskii, B.L.,Vinitskii L.E. Kauch i Rezina, 24, no. 5, May 65, p 22 Effect of the filler content of reclaim vulcanizates on the dielectric properties of the reclaim.

Babitskii, B.L.Vinitskii, L.E. and Kaplunov, Ya. N. Dielectric properties of reclaim Kauchuk i Rezina, 21 (12): 18-22 (1962): Soviet Rubber Technol. (English Transl.). 21 (12): 18-21 (1962). (C.A., 58: 11552; R.A., 42:143). Reclaim increases the safety factor.

Babitskii, B.L., Vinitskii, L.E. Effect of filler content of reclaim vulcanizates on the dielectric properties of the reclaim. Sov. Rubb. Tech. Vol. 24 no. 5 p. 23 (1965).

Coe, W.S. Effect of Reclaimed Rubber on Temperature Coefficient of Vulcanization Ind. Eng. Chem., 31: pp. 1481-85 (Dec. 1939). (C.A., 34:1513; R.A. (N.Y.), 45:283; I.R.W., 100: No. 6, 45: I.R.J., 98:314; S.C.I., 17:682,828; B.C.A. (B) 156-1940).

Hublin, R.A. Evaluation of Mixings Containing Reclaim. Rev. Gen. Caout. 16; pp. 297-302, 329-35 (Oct. and Nov., 1939). (S.C.L., 18:32).

Kaplunov, Y.N., Shokhin, I.A., and Povarova, Z.G. Mechanical properties of tread rubbers incorporating reclaim. Tr. Mosk. Inst. Tonkoi Khim. Tekh., Nov. 6: pp. 130-40 (1956). (R.A., 36:430).

Montu, M. Reclaimed rubbers. Rev. Gen. Caout., 37: No. 4, pp. 487-88 (1960). (R.A., 38:433). Properties of reclaim.

Rhein Chemie Gmbh VIII-1 the addition of chloroprene reclaim in a chloroprene rubber extrusion compound and its effects.

Rhein Chemie Gmbh Tech Bull VIII-2 the addition of nitrile reclaim to a nitrile compound and its effects on properties.

Rose, H.W., Welch, W., Shaffer, C.R., Johnson, T.A., Busenberg, E., and Nesbit, J. Akron Group panel discussion on reclaimed rubber. Rubber World, 125: pp. 726-30 (1952). (R.A., 30:224). Methods, properties and use of reclaimed rubber.

Marakhovskii, M. Zakharov, N., and Pekarskaya, G. Rubber from waste. Prom. Kooperatsiya, No. 2: p. 25 (1956). (R.A., 35:337).

Peck, A.P. Domestic rubber "plantations": scrap rubber reclaimed. Sci. American, 167: pp. 105-07. (S.C.L., 21–145), Illustrated description of reclaiming process.

Rostler, F., and Mehner-Wilson, V. Reclaim from vulcanized rubber scrap. German Pat. 909,041 (March 4, 1954). (To Metallgesellschaft Aktienges. Naftolen Ges. m.b.H.). (R.A., 33:59). Refinery wastes.

Barron, H. Waste Rubber. I. The Economic Aspect. (Types of scrap and methods of collection) R.A. (London), 19:pp. 316-17, 341 (Jan. 1939) (S.C.L., 17:67). III. Uses of Reclaim. Ibid 20:pp. 20-21 (Mar. 1939). (S.C.L., 17:269).

Coe, J.P. Present status of rubber chemicals and reclaimed rubber. Ind. Eng. Chem. (Ind. Ed.), 33:pp. 1347-51 (Nov., 1941).

Gutman, A. Problem of Increasing and Improving the Production of Reclaimed Rubber. Kauchuk i Rezina, No. 10, pp. 9-13 (1937). (C.A., 32:4380; S.C.L., 16:525).

Japanese Reclaimed Rubber (Specifications of the Society of the Rubber Industry of Japan). I.R.J., 97:p. 419 (Apr. 8, 1939). (S.C.L., 17:236).

Kirchhof, F. Reclaim rubber as raw material. Kautschuk u. Gummi, 3: pp. 348-50 (1950); 4: pp. 372-74 (1951). (S.C.L., 28:966).

Plumb, J.S. Economic factors in reclaiming synthetic rubbers. I.R.W., 112: pp. 307-08 (1945). (C.A., 39:4515; S.C.L., 23:343). Discusses collection and grading of scrap, processing, and marketing.

Rhein-Chemie GmbH Reclaim. A Constant and Economic Raw Material for each rubber compound (Retorte 32E) Mannheim-Rheinau: 1962. 46 pp. (R.A., 41:197). General information about reclaimed rubber and its uses are presented.

Shulan, A. A scrap rubber dealer's viewpoint. I.R.W., 105:p. 159 (Nov. 194). On the expanding market for reclaimed rubber.

Tonn, R.C. Scrap rubber. Its contribution to the national economy. Rubber J. Intern. Plastics 140 (7). 250 (1961). (R.A., 39.233).

Torrey, Richard F. Transportation Factors in Plant Location Rubber Age, June 1965 p. 86.

Pyrolysis

Albert, H. and Tacke, W. Method of reclaiming scrap polyurethene U.S. Pat. 2,998,395 (Aug. 29, 1961). (To Reeves Bros. Inc.) (C.A., 56:4957; R.A., 40:151). Burning the resin in the air.

STUDY BY GAS CHROMATOGRAPHY OF THE PRODUCTS OF POLYMER PYROLYSIS

(French)

R. Audebert

Ann Chim (Paris), 3(1):49. January-February, 1968. 18 pages. The study by gas chromatography of the products of the pyrolysis of macromolecular compounds has undergone enormous development during the last 15 yr. After describing the main types of apparatus employed and their uses, the characteristics parameters are shown which allow one to define the best conditions for pyrolysis and for chromatography. Typical examples are given to illustrate the applications of this technique. epg

THE INFLUENCE OF BROMINE COMPOUNDS ON THE COMBUSTION OF POLYOLEFINS

1. EFFECTS ON THE THERMAL DEGRADATION

M D Carabine (Imperial Coll, London) C F Collins and I J Groome (The City Univ, London) Proc Roy Soc (London) Ser A, 306 (1484): 41, July, 1968 11 pages Hattobe, Y. Kerosene–like product from rubber waste, Japanese Pat. 175,545 (To Oriental Rubber Industrial Co.). (C.A., 44:8156; S.C.L., 28:1004).

Iyer, K.N. Degradation of rubber. "High Polymers Symposium and Exhibition", Poona, p. 26 (1957). (R.A., 35:475). Non-oxidative degradation of rubber is critically examined.

THERMAL DEGRADATION OF POLYSTYRENE

G J Knight (Royal Aircraft Establish., Farnborough, Hampshire, Engl.) J Polymer Sci, Part B, 5, #9, 855 (1967) September 3 pages Polystyrene will degrade entirely to monomer under flash pyrolysis conditions if small enough samples are taken and if the temperature is sufficiently high. With large samples secondary reactions take place due to diffusion effects. This would explain the dimer, trimer and tetramer observed in earlier experiments. At lower temperatures with small samples it seems probable that the time required to produce degradation and the lifetime of the styryl radicals are such that secondary reactions may occur.

Lane, G.H. Rubber Journal, 150, no. 2, Feb. 68 p 44 The case against burning used tires. Palma process versus incineration centers.

Mochizuki, G. and Konishi, M. Rubber asphalt from waste rubber Japanese Pat. 8, 878/57 (Oct. 18, 1957). (C.A., 52:12446; R.A., 36:586). Heating to obtain rubber tar.

Mzourek, A. and Hladacek, M. Thermal degradation of rubber scrap V. Contribution to extending chloroprene rubbers, with reclaim distillates, Plaste Kautschuk 8 (7), 359 (1961). (C.A., 55:15975; R.A., 39:532). Improved life of chloroprene rubber.

Mzourek, Z. and Mikl. O. Thermal decomposition of rubber scrap, IV. Analysis of products obtained by scrap rubber pyrolysis. Plaste Kautschuk 8 (1), 3-6, (2) 69-74 (1961). (C.A., 55:26495; R.A., 39:246,294). (See also R.A., 38:175,484,604).

Pickett, F.N. Emergency reclaim plan, R.A. (London) 23:pp.33,34,40,57-59,66, 129-30,153-55,163 (1942). (S.C.L., 20:185, 214:341). Discusses manufacture of a rubber distillate.

Pespisl, J. Pyrolysis of surplus rubber and the employment of technical dispentene. Chem. Listy 55 (10), 1210-20 1961; Chim. Ind. 88 (1), 66 (1962). (C.A., 56:11761; R.A. 40:492).

Schmidt, H. Dry distillation of vulcanized rubber. Kautschuk u. Gummi, 4: pp. 21-23 (1951). (C.A., 45:6419; S.C.L., 29:230).

APPARATUS FOR STUDY OF THE KINETICS OF POLYMER DEGRADATION (Russian)

RAPRA

A I Sidney, Yu V Khvashchevskaya and I A Zubkov Plast Massy, (6):61, June, 1968 2 pages. The authors describe a static vacuum apparatus for the investigation of the thermal and thermooxidative degradation of polymers with automatic recording of the rate of absorption of oxygen, or of the rate of evolution of gaseous degradation products. myf

THERMAL ANALYSIS OF POLYMERS

D A Smith

Rubber J. 150 (4):21. April, 1968. 8 pages.

THERMAL DECOMPOSITION PRODUCTS OF POLYETHYLENE

Y Tsuchiya and K Sumi (Nat Res Council, Ottawa, Canada). J. Polymer Sci. Part A-1, 6 (2):415. February, 1968. 10 pages. Decomposition products of polymers have been determined by many investigators, but the results are often conflicting because of difficulties in analyzing a large number of products. A comprehensive analysis of the volatile thermal decomposition products of high-density polyethylene has been made with the latest techniques in gas chromatography. The formation of products is explained on the basis of free radical mechanism. The predominant process in the formation of volatiles appears to be intramolecular transfer of radicals, in which isomerization by a coiling mechanism plays an important role in determining the relative quantities of each product. svk

Tsvetaeva, E.M., Sidorova, R.I. Drugovskaya, M.N. and Shokhin, I.A. Synthetic softeners for reclaiming made from rubber pyrolysis products. Kauchuk i Rezina 19 (12), 31-4 (1960): Soviet Rubber Technol 19 (12), 28-31 (1960). (C.A., 55:20477; R.A., 39:533). The method described is based upon the polymerizing and sulfonating action of concentrated sulfuric acid on rubber oil.

Reclaiming Chemicals, General

Baldwin, F.P. Reclaiming butyl rubber by treatment with metalloid hydrides. U.S. Pat. 2,493,518 (Jan. 3, 1950) (To Standard Oil). (C.A., 44:2273; S.C.L., 28:198).

Bata, A.–G. Reclaiming of synthetic rubber. French Pat. 885,895 (Sept. 28, 1943). (Chem. Zentr. 115: Part I, 1140-41). Heating butadiene or chloroprene rubber with dithiocarbamic acid derivatives, a thiazole, thiazyl sulfide, thiuram sulfide or dibenzothiazoyl disulfide.

Bata, A.–g. Reclaiming of natural or synthetic rubber. French Pat. 885,896 (Sept. 28, 1943). (Chem. Zentr., 115: Part I, 1047). Treating vulcanized rubber, chloroprene, buna or butadiene rubber with organic sulfonyl chlorides under heat and pressure.

Baudelot, P. Reclaiming synthetic rubber. French Pat. 931,228. (S.C.L., 27:685; Rev. Gen. Caout., 26:532). Simultaneous application of heat and pressure in the presence of a plasticizing catalyst.

Beaven, E.W.J. Rubber reclaiming oils, Brit. Pat. 932,853 (July 31, 1963). (To Shell Research, Ltd.). (C.A., 59:11744; R.A., 41:563). The composition has an aniline point of less than 15°C.

Beaven, E.W.J. Reclaimed oil composition for rubber. U.S. Pat. 3,116,258 (Dec. 31, 1963). (To Shell Oil Co.).

Bechtold, H.A. Reclaiming buna scrap. French Pat. 903,859 (1946). (S.C.L., 24:500; Rev. Gen. Caout., 23:82). Schist oils with natural rubber.

Beloroxxova, A.G., and Farberov, M.I. Synthesis of alkyl cresol disulfides as reclaiming agents for vulcanized rubber. Uch. Zap. Yaroslavski, Tekn. Inst., 3: pp. 77-82 (1959). (R.A., 38-484; C.A., 53:19940). Synthesis of ter-butyl cresol disulfide.

Bennett, R.B., and Smith, G.E.P., Jr. Relationship of oxygen to activity of GR-S reclaiming agent. Ind. Eng. Chem. 46: pp. 1721-26 (1954); repr. in Rubber Chem. Tech., 28: pp. 308-21 (1955) (C.A., 48:14279; R.A., 32:510).

Bergmann, F., and Dishon, B.R. Reclaiming rubber. Brit. Pat. 580,617. (S.C.L., 24:607; 26:450; Rev. Gen. Caout, 25:33). N-Butyl alcohol and steam.

Berryman, G.C. Process for forming a fibrous rubber base. U.S. Pat. 2,395,987 (Mar. 5, 1946). (C.A., 40:3640; S.C.L., 24:318). Mixing ground up tire carcass stock with pine-tar, forming the mass into a slightly compressed layer, and cooking the layer in steam at about 338°F for about four hours.

Beverly, J.A. USP 3318838 Reclaiming and Treating Synthetic Rubbers. Scrap is heated in reclaiming oils to 420° to drive off water and soften particle for use.

Boyd, J.H. Rubber reclaiming solvents. U.S. Pat. 2,623,862 (Dec. 30, 1952). (To Phillips Petroleum Co.). (C.A., 47,3605; R.A. 31:256). Cyclopentadiene.

Brown, G.L., Johnson, T.A., and Knill, R.B. Non-discoloring reclaim. U.S. Pat. 2,640,035 (May 26, 1953). (To Wingfoot Corp.). (C.A., 47:7814; R.A., 32:57). Devulcanizing with a light colored rosin oil.

Bruckner, Z. and Juhasz, M. Role of surface active materials in the water-neutral rubber reclaiming process. Gumiipari Kutato Intezet Koxlemenyei (1949-59), 1:206-40 (1962). The product is more homogeneous.

Bruner, L.B. Acyloxy-end block diorganopolysiloxanes, U.S. Pat. 3,032,532 (May 1, 1962). (To Dow Corning Corp.) (C.A., 57:11236; R.A. 40:604).

Bulli, M., and Societa Italiana Pirelli. Reclaim of rubber waste. Italian Pat. 384,725. (S.C.L., 23:235; Rev. Gen. Caout., 21:42). By an alkali product in situ, e.g., sodium carbonate and calcium carbonate.

Campbell, C.H., and Ostermayer, R.W. Rubber reclaiming oil. U.S. Pats. 2,447,732 and 2,447,733 (Aug. 24, 1948). (C.A., 42:8518; S.C.L., 26:816).

Campbell, A.W. Study of the nitroparaffins and their derivatives as heat sensitizers for compounded rubber latices. Abstract only in I.R.J., 100: pp. 193-94 (1940). (S.C.L., 18:601).

Campbell, C.H. Oil-resin reclaiming blend. U.S. Pat. 2,468,482 (Apr. 26, 1949). (S.C.L., 27:603).

Castello, A.D., and Dixon H.L. Reclaimed rubber. U.S. Pat. 2,278,826 (Apr. 7, 1942 To Goodrich). (C.A., 36:6376). Preparing a nonstaining composition by admixing vulcanized rubber, an absorbent material, and a water-insoluble soap, and heating the mixture in the presence of an alkali.

Castello, A.D. Peptized vulcanizate and method of preparing it. U.S. Pat. 2,211,592 (Aug. 13, 1940). (To Goodrich). Reclaiming well-vulcanized soft rubber by adding an organic material to accelerate the vulcanization and masticating below 180°F.

Cech, C.J., and Bata, A.–G. Regeneration of synthetic rubber composed of polymers of butadiene or its alkyl or halogen derivatives. German Pat. 743,605. (S.C.L., 22:209; 23:380; Rev. Gen. Caout., 21:189). Heat treating with derivatives of thiazole or dithiocarbamic acid.

Ceva, A., and Trius, V. Plasticizers in reclaiming rubber scrap. Bol. Inst. Espan. Caucho, 3: pp. 247-58 (1957). (R.A., 36:258).

Clarke, R.B.F.F. Regeneration of vulcanized natural and synthetic rubber. Brit. Pat. 581,136 (1946). (To Imperial Chemical Industries, Ltd.). (C.A., 41: 1874; S.C.L., 24:607). High pressure steam and an alkyl-olamine.

Clayton, R.E. Process for reclaiming scrap rubber with polymer oil-sulfur mixture and composition thereof. U.S. Pat. 2,939,850 (June 7, 1960). (To Esso Research & Eng. Co.). (C.A., 55:21834; R.A., 39:79). Scrap rubber is softened by an oily mixture.

Cohan, L.H., and Mackey, J.F. Carbon black in all-reclaim tire treads. I.R.W., 107: pp. 469-70, 479 (Feb. 1943). (C.A., 37:2217).

Continental Carbon Co. (1) Continental grades of carbon black in all-reclaim thread stock. (2) Competitive soft channel blacks in all-reclaim tread stocks. (Technical bulletins). (S.C.L., 21:299).

Continental Gummi Werk G.P. 1229720 Reclaiming polyeurethane scrap. Regenerated by breaking down with esters with OH groups i.e. ethylene glycol etc.

Continental, Gummi Werk A.–G. Scrap rubber. Ger. Pat. 1,150,197 (June 12, 1963); Ger. Pat. Abstr. 3 (28): 2 (1963). (C.A., 59:6599; R.A., 41:512). Before reclaiming, scrap rubber based on discoloration (while at the same time avoiding attack on the rubber itself) by treating with organic peroxides in organic solvents or rubber swelling agents.

Cook, W.S. Reclaiming rubbers. U.S. Pats. 2,560,048, 2560,049 and 2,560,050 (July 10, 1951). (To Firestone). (C.A., 46:3077; S.C.L., 29:838). Use of sulfur chloride and a polyalkylcyclohexanol or bis (4,6-di-tert-butyl-3-methylphenol) sulfoxide or bis phenol sulfoxide.

Cook, W.S., Albert, H.E. Kilbourne, F.L., Jr. and Smith, G.E.P., Jr. Reclaiming agents for synthetic rubber. Ind. Eng. Chem., 40: pp. 1194-1202 (1948): repr. in Rubber Chem. Tech., 22: pp. 166-85 (1949). (C.A., 42:9235; S.C.L., 25:628; 26:634; R.A., 61:204).

Cook, W.S., and Smith, G.E.P., Jr. Bis (tetraalkylphenol) monosulfides. U.S. Pat. 2,605,288 (July 29, 1952) (To Firestone). (C.A., 46:11755; R.A., 30:253). Tetraalkyl phenol sulfides.

Cook, W.S., and Smith, G.E.P., Jr. Reclaiming natural and synthetic rubber with bis (tetra-alkylphenol) sulfied. U.S. Pat. 2,713,561 (July 19, 1955). (To Firestone). (C.A., 50:4546; R.A., 34:121).

Corkery, F.W. Synthetic rubber reclaimed with a reclaiming oil. U.S.Pat. 2,449,879 (Sept. 21, 1948). (To Pennsylvania Industrial Chemical Corp.). (C.A., 42:9237; S.C.L., 26:880). Composed of crude solvent naptha and a higher boiling aromatic oil.

Dasher, P.J. Reclaimed rubber. U.S. Pat. 2,304,548 (Dec. 8, 1942). (To Goodrich). (C.A., 37:2960). Heating vulcanized rubber and hydroxylamine or its salts at a temperature not lower than 200°F.

Dasher, P.J. Reclaimed rubber. U.S. Pat. 2,304,549 (Dec. 8, 1942). (To Goodrich). (C.A., 37:2960). Heating soft-vulcanized rubber with any various alkylol amines. Aliphatic polyamines, hydroxylamines and mercaptoamines at a temperature not lower than 200°F until the rubber becomes plastic.

Dasher, P.J., Reclaimed rubber. U.S. Pats. 2,304,550 and 2,304,551 (Dec. 8, 1942) (To Goodrich). (C.A. 37:2960). By heat treatment with an alipahtic polyamine or an aliphatic mercaptomne.

Dasher, P.J., Reclaiming vulcanized copolymers of butadiene and acrylonitrile, U.S. Pat. 2,465,205 (Mar. 22, 1949). (To Goodrich). (C.A. 43:4510; S.C.L. 27:422). Acrylic ester.

Dasher, P.J., Reclaiming composite material. U.S. Pat. 2,498,398 (Feb. 21, 1950). (To Goodrich). (C.A. 44:3738; S.C.L. 28:399). Mineral acid to degrade the cellulosic fiber.

Dasher, P.J., Methods for reclaiming unvulcanized rubber scrap, or the like; containing fiber, by treatment with mineral acid vapor. U.S. Pat. 2,701,268 (Feb. 1, 1955). (To Dasher Rubber & Chemical Co.). (C.A. 49:8628; R.A., 33:344).

Dasher, P.J., Apparatus for reclaiming unvulcanized rubber scrap, or the like containing fiber. U.S. Pat. 2,927,342 (March 8, 1960). (To Dasher Rubber & Chemical Co.). (R.A. 38:537; C.A. 54:1829). Scrap subjected to hydrochloric acid.

Deutsche, Shell A-G and Metallgeselischaft A-G. Synthetic rubber. German Pat. 1,077,864 (March 17, 1960). (R.A. 38:350). Synthetic regenerated using oil.

Devulcanizing agents for rubber. Oil, Paint & Drug Reptr., 141: p. 60 (May 25, 1942). An alphabetical list.

DeWaele, A. Plasticizing, reclaiming and reworking vulcanized rubber. Brit. Pat. 605,588 (1948). (To Gestetner, Ltd.). (S.C.L., 26:901). Heating in the presence of oxygen and a polycyclic secondary amine.

Dinzburg, B.N. Kauch i Rezina, 26, no. 2, Feb. 1967, p. 16-18. The electron microscopic study of vulcanizates containing phenolformaldehyde resins. The effects are discussed.

Dogadkin, B.A., Drozdovskii, V.F. Tarasova, Z.N. and Arkhangelskaya, M.I. Effect of mercaptans and disulfides on the thermal and thermal oxidative degradation of swollen vulcanizates. Kauchuk i Rezina, 21 (5); 15-22 (1962); Soviet Rubber Technol, 21 (5): 14-20 (1962).

Drozdovskii, V.F., Dogadkin, B.A. and Sokolov, S.A. Regeneration of scrap rubber. Russian Pat. 116,024 (Nov. 22, 1958). (R.A., 38:17; C.A., 53:17560). Organic thioyanates.

Drozdovskii, V.F., Sokolov, S.A., and Dogadkin, B.A. Effect of sulfur containing derivatives of carbazole on the process of reclaiming rubbers. Kauchuk i Rezina, 18: No. 4,

pp. 29-31 (1959); trans in Soviet Rubber Tech., 18: No. 4, pp. 30-32 1959). (C.A., 53:17560; R.A., 37:588). A time tread prepared from sodium-butadiene plus natural rubbers was reclaimed by neutral method using activators.

Drozdovskii, V.F., and Sokolov, S.A. Reclaiming vulcanized rubber using activators. Russian Pat. 118,172 (Feb. 20, 1959). (C.A., 37:375). This zinc salt of trichorothiophenol.

Drozdovskii, V.F., and Sokolov, S.A. Efficiency of the zinc salt and disulfide of trichlorothiophenol in reclaiming rubber by the neutral (water digestion) process. Kauchuk i Rezina, 18: No.8, pp. 40-43 (1959): trans. in Soviet Rubber Tech., 18: No. 8 pp. 39-42 (1959). (R.A., 38:175; C.A., 54:7208). Tread rubbers were used for this investigation.

Drozdovskii, V.F., and Shokhin, I.A. Method of reclaim of butyl rubber vulcanizates under the action of radioactive irradiation. Russian Pat. 128,140 (April 28, 1960). (R.A., 38:407; C.A., 54:23404). Use of an alkyl phenol disulfide.

Drozdovskii, V.F., Sokolov, S.A. Shokhin, I.A. and Eitingon, I.I. Peptizers for use in reclaiming rubber. Kauchuk i Rezina, 20 (12): 22-5 (1961): Soviet Rubber Technol. 20 (12); 21-4 (1961). (C.A., 57:1006: R.A., 41:47). Thiophenols are used.

Drozdovskii, V.F., Lavrova, T.V. and Sokolov, S.A. Anydrides of carboxylic acids and the reclaiming of rubber. Kauchuk i Rezina 20 (3), 33-5 (1961); Soviet Rubber Technol. 20 (3), 30-2 (1961). (C.A., 55:25321; R.A., 40:151). Anydrides are less efficient than trichlorothiophenol.

Drozdovskii, V.F. Sulfur-containing activators for use in reclaiming Soviet Rubber Technol. (English Transl.), 21 (11): (1962).

Drozdovskii, V.F., Reclaiming Rubber USSR-P 167297 publ. 4:1:65. Catalysts are triphenylphosphine and (or) B-napthalide of thioglycoltic acid.

Drozdovskii, V.F. Kauch i Rezina 26, no. 5, May 1967, p. 21. Triphenylphosphine trichlorothiophenol and Di (trichlonophenyl) disulphide or vulcanzates. System is effective as low as 22°C.

Dubrovin, G.I. Reclaiming rubber wastes and their use. Kauchuk i Rezina, No. 10: pp. 49-50 (1940). (C.A. 37:4929; S.C.L. 21:299; Chem. Zentr. I; 2046). Treated with softener and lampblack.

Dufour, R., and Leduc, H.A. Method and apparatus for heating, in particular for pre-vulcanizing, or reclaiming rubber mixes or similar materials. German Pat. 948,557 (Aug. 16, 1956). (R.A., 35:368). Fillers and additives.

Ecker, R., and Gumlich, W. Regenerating vulcanized rubber. U.S. Pat. 2,338,427 (Jan. 4, 1944). (C.A., 38:4151). Reclaiming of synthetic rubbers by heating in the presence of an aromatic mercaptan.

Ecker, R., and Bahr. K. Reclaim of used or scrap rubber. German Pat. 910,962 (April 1, 1954). (To Farbenfabriken Bayer, A.-G.). (Addition to German Pat. 898,677). (R.A., 33:146). Alkali Rhodanides.

Elgin, J.C., and Sverdrup, E.F. Reclaiming scrap vulcanized material using an olefin as reclaiming agent. U.S. Pats. 2,653,914, 2,653,915 and 2,653,916 (Sept. 29, 1953). (C.A.,48:395,396; R.A., 32:301). Hexenes, heptenes and octanes.

Elgin, J.C. Reclaiming rubber. U.S. Pat. 2,593,279 (Apr. 15, 1952). (To U.S. Rubber Reclaiming Co., Inc.) (C.A., 46:5882; R.A., 30:224). Aliphatic mercaptans and disulfides.

Endo, H. Studies of reclaimed rubber. XIV. Effect of compounding ingredients on reclaimed rubber. 3. Effect of vegetable oil and fish oil on relcaimed vulcanizates. J. Soc. Rubber Ind., Japan, 15: pp. 100-17 (1942). (C.A., 43:2021; S.C.L., 27:511).

Essex, W.G. New development in rubber reclaiming. Trans. Inst. Rubber Ind. 16: pp. 252-59 (Feb. 1941). Treatment of standard alkali reclaim with oxygen.

I.G. Farbenindustrie, A.G. Reclaiming vulcanized rubber articles by nitrochlorobenzene. French Pat. 876,300. (S.C.L., 23:305; Rev. Gen. Caout., 20:6).

I.G. Farbenindustrie A.-G. Reclaiming vulcanized rubber. French Pat. 853,577. (C.A., 36:2758; S.C.L. 20:318). By heating in the presence of oxygen and a monoarylhydrazine.

I.G. Farbenindustrie, A.–G. Reclaiming of vulcanizates of natural and synthetic rubber. French Pat. 876,300 (Nov. 2, 1942). (S.C.L., 23:305; Rev. Gen. Caout., 20-6; Chem. Zentr. 114: Part II, 1327. Warming with aromatic chloronitro compounds.

I.G. Farbenindustrie A.-G. Reclaiming vulcanized rubber. German Pat. 708,955 (C.A. 37:3300; S.C.L. 21:238). By heating in presence of oxygen and monacrylophydrazine.

Farbenindustrie, I.G. Reclaiming of rubber from vulcanized products. Brit. Pat. 527,417. (S.C.L., 18:845). By heating in the presence of a monoaryl Hydrazine and oxygen.

I.G. Farbenindustrie, A.-G. Reclaiming vulcanized rubber products. French Pat. 1,013,958 (Aug. 6, 1952). (R.A., 31:217; Rev. Gen. Caout, 30:64). Diaryldisulfides containing nitrated groups.

Flood, D.W., and Mulligan, R.A. Method of and apparatus for reclaiming latex foam. U.S. Pat. 2,719,830 (Oct. 4, 1955). (To U.S. Rubber). (C.A. 50:3793; R.A. 34:328). Alkali or borate.

Garvey, B.S. Method of reclaiming rubber. U.S. Pat. 2,193,624 (Mar. 12, 1940) and Can. Pat. 389,891 (July 9, 1940). (To Goodrich). By heating in the presence of a thiophenol.

Ghez, H. and Ghez, O. Regeneration of rubber. Brit. Pat. 528,319. (S.C.L., 18:845). Immersing scrap rubber in a wire mesh receptacle in a bath of hot molten material until the fabric is carbonized, then withdrawing from the bath, draining excess liquid off, and cooling rubber.

Ghez, H. and Guez, O. Caoutchouc regeneration. U.S. Pat. 2,296,275 (Sept. 22, 1942). (C.A. 37:1298). By heating in a liquid bath of bituminous material at 180° to 225°C. until it can be readily plasticized by milling.

Gibbons, P.A. Process of reclaiming rubber. Canadian Pat. 457,307. In the presence of oxygen.

Green, J. Reaction product of sulfur-vulcanized rubber polymer and a material having carbon to carbon unsaturation alpha to an electron group. U.S. Pat. 2,879,245 (March 24, 1959). (To U.S. Rubber Reclaiming Co.). (C.A., 53:14572; R.A., 37:507). The use of maleic anhydride.

Gumlich, W., and Ecker R. Reclaiming rubber. German Pat. 722,575 (May 28, 1942). (C.A., 37:5284). Vulcanized rubber heated with an aromatic thiol.

Gumlich, W. Reclaiming of rubber. U.S. Pat. 2,280,484 (April 21, 1942). (To General Aniline & Film Corp.). (C.A., 36:6376). Usingthe condensation product of a monarylhydrazine and an aldehyde or ketone.

Haang, C.Y. Tanabe H. Nippon Gomm Kyokaiski 40, no. 3, 1967, p. 189 Addition of phenol-formaldehyde resins to reinforce SBR rubbers.

Haehl, A. Effects of prooxygenic substances on reclaimed rubber. Rev. Gen. Caout., 21: p. 168 (Aug. 1944); trans in Rubber Chem. Tech., 19: pp. 123-24 (1946). (C.A., 39:5541; 40:3928).

Hensley, W.A. Reclaiming rubber with reaction products of dialkylnaphthols with sulfur chloride. U.S. Pat. 2,647,089 (July 28, 1953). (To Firestone). (C.A., 47:10888; R.A., 32:214). For vulcanized GR-S or mixtures of natural rubber and GR-S.

Hermes Patentverwertungs, G.m.b.H. Reclaiming of synthetic rubber. French Pat. 886,587 (Oct. 18, 1943). (Chem. Zentr., 115: Part I, 1047). Heating with high melting bitumens.

Higgins, C.J., and Forman, D.B. RR-10-reclaiming agent and processing aid. (E.I. DuPont de Nemours & Co., Inc. Rubber Chemicals Div., Report 54-55, Wilmington, Delaware, 1954). (R.A., 33:59). Dixylyl sulfides.

Hudecek, J. and Dlab, J. Method of treating vulcanized rubber scrap by distillation. Czech. Pat. 96,911 (Oct. 15, 1960); Ref. ZH. Khim., 1962 abstr. 14P415. (R.A., 41:58). Hydrochloric acid is used.

Jaeger, R.W. Rubber reclaiming solvent. U.S. Pat. 2,374,101 (April 17, 1945). (To Standard Oil). (C.A., 39:4776; S.C.L., 23:306). A specially prepared petroleum fraction for use as a devulcanization accelerator.

Johnson, A., and North British Rubber Co., Ltd. Reclaiming of waste rubber. Brit. Pat. 555,643 (Sept. 1, 1943). (C.A., 39:1080; S.C.L., 21:299). Ground scrap heated with exhaust gases.

Johnson, T.A., and Thompson, H.H. Reclaiming synthetic rubber by means of phenyl-beta-naphthylamine. U.S. Pat. 2,478,826 (Aug. 9, 1949) (To Wingfoot Corp.). (S.C.L., 27:1035).

Johnson, T.A. Reclaiming synthetic rubber. U.S. Pat. 2,478,827 (Aug. 9, 1949) and Canadian Pat. 457,303. (To Wingfoot Corp.). (C.A., 45:1378; S.C.L., 27:1018). Acidic aluminum or zinc salt of an inorganic acid.

Johnson, T.A., and Thompson, H.H. Regeneration of synthetic rubber. U.S. Pats. 2,533,016-7 (Dec. 5, 1950). (To Wingfoot Corp.) (S.C.L., 29:98) Ethylene glycol.

Joyce, W.J., and Geyer, H.D. Shredding rubber. U.S. Pat. 2,318,693 (May 11, 1943). (C.A., 37:6157; S.C.L., 21:211). Explosion with ammonia.

Kowaoka, Y. Vulcanization Accelerators. II. Reclaimed Rubber and Vulcanization Accelerators. J. Soc. Rub. Ind. Japan, 11: pp. 556-66, 624 (1938). (C.A., 33:2367; S.C.L., 17:105,304). III. Reaction of Phenylthiourea with Carbon Disulfide. IV. New Method for the Snythesis of Mercaptobenzothiazole from Phenylthiourea and Sulfur. Ibid, 12: pp. 20-26, 96-102, with abstracts in English on pp. 73-74, 148-50 (1939). (C.A., 33:4077,9045; B.C.A. (B), 408-1939).

Kawashima, Y. Reclaiming rubber. Japanese Pat. 215/1950 (Jan. 30, 1950) (C.A., 46:8890; R.A., 30:509). Milled with leaves of cryptomeria.

Keilen, J.J. and Dougherty, W.K. Active carbon as anti-stain agents for reclaimed rubber. (Abstracts only). Rubber Age, 72: p. 73 (1952); Rubber World, 127: p. 87 (1952) (C.A., 48:1722; R.A., 31:17).

Kelefti, Z., and Wolfner Gyula Estarsa Gumigyar, R.T. Reclaiming vulcanized rubber. Hungarian Pat. 135,618 (C.A., 44:6192; S.C.L., 28:710). Heated by a bath of an alloy metal.

Kelly, J.H., Jr. Reclaiming rubbers. U.S. Pat. 2,477,809 (Aug. 2, 1949) (To General Tire). (C.A., 45:2254; S.C.L., 27:438). Water-insoluble aliphatic amine and a phosphoric acid.

Kelly, J.H., Jr., Reclaiming elastomers. U.S. Pat. 2,535,931 (Dec. 26, 1950). (To General Tire). (C.A., 43:8196; S.C.L. 29:195). Alkyl phosphates, alkyl phosphoric acids, and alkyl phosphoric acid salts.

Khodkevich, L. Production of colored reclaim by means of chemical accelerators of reclaiming. Leka. Prom. 8: No. 5, pp. 26-27 (1959). (R.A., 38:383). The cost about the same as black reclaim.

Kilbourne, F.L. Method of reclaiming synthetic rubber. U.S. Pat. 2,324,980 (July 20, 1943). (To Firestone). (C.A., 38:512). Heating a mixture of rosin, asphalt residue from cracking crude petroleum solvent naphtha and vulcanized neoprene.

Kimishima, T. Reclaimed rubber. Japanese Pat. 178,563 (Apr. 16, 1949). (C.A., 45:9910; R.A., 30:99). With thiophene toluene.

Kirby, W.G. Process of reclaiming rubber. U.S. Pat. 2,276,248 (Mar. 10, 1942) (To U.S. Rubber). (C.A., 36:4736). Dampening a broken-down fiber-containing waste rubber stock with ammonium chloride; converting a semiplastic condition by the combined action of heat, air, and steam under pressure, with partial disintegration of the fibers; continuing plasticization of the stock by steam under pressure; and milling to disperse the fibers uniformly.

Kirby, W.G., and Elliott, P.M. Process of reclaiming water polychloroprenes. U.S. Pat. 2,343,558 (March 7, 1944) and Can. Pat. 431,501 (Nov. 27, 1945). (To U.S. Rubber). (C.A., 38:3162). Heating in the presence of an acid of the formula R-COOH where R is H, OH, COOH or an aliphatic hydrocarbon group. B.P. 566,058.

Kirby, W.G., and Steinle, L.E. Process of reclaiming waste polychloroprenes U.S. Pat. 2,343,559 (March 7, 1944) and Can. Pat. 431,502 (Nov. 27, 1945). (To U.S. Rubber). (C.A., 38:3163). Heating in the presence of a sugar. B.P. 563,802 (Dec. 6, 1943).

Kirby, W.G. and Steinle, L.E. Process for reclaiming waste polychloroprenes U.S. Pat. 2,363,873 (Nov. 28, 1944) and Can. Pat. 428,685 (July 10, 1945). (To U.S. Rubber). (C.A., 39:3967; S.C.L., 23:58). Heating in the presence of a di-(hydroxyaryl) sulfide.

Kirby, W.G. and Steinle, L.E. Process of reclaiming waste polychloroprenes. Can. Pat. 431,500 (Nov. 27, 1945) and U.S. Pat. 2,391,714 (Dec. 25, 1944) (To U.S. Rubber). (C.A., 40:1349). Reclaiming scrap polychloroprenes by mixing in cellulose fibers and heating in the presence of water at 300° to 420°F. B.P. 557,802.

(1) Kirby, W.G. and Steinle, L.E. Process for reclaim scrap vulcanized copolymers of 1,3- butadiene and compounds copolymerizable therewith U.S. Pat. 2,359,122 (Sept. 26, 1944) and Can. Pat. 428,683 (July 10, 1945). (To U.S. Rubber). (C.A., 39:1780; S.C.L., 22:385). Reclaiming scrap containing a vulcanized copolymer of 1,3- butadiene and a compound which contains a single CH_2=C (group which comprises heating in the presence of a di-hydroxyaryl sulfide.

Kirby, W.G., and Elliott, P.M. Waste polychloroprene reclaiming process. Can. Pat. 431,499 (Nov. 27, 1945). (To U.S. Rubber). Heating in a comminuted condition in the presence of water at 300° to 420°F in the presence of an amide.

Kirby, W.G. and Steinle, L.E. Process for reclaiming scrap vulcanized rubber. U.S. Pat. 2,372,584 (March 27, 1945) and Can. Pat. 428,684 (July 10, 1945). (To U.S. Rubber). (C.A., 39:3462; S.C.L., 23:235). Heating at 300° to 420°F. the scrap in which has been incorporated a small amount of a di-(hydroxvaryl) sulfide.

Kobrinskii, L.S. Method of reclaim of high polymers from fabric containing secondary raw materials. USSR Pat. 139,819 (Aug. 5, 1961). Ref. Zh. Khim., 1962 (13): Abstr. 13P125. The polymer containing fabric of cellulosic fibers, is comminuted and placed in a drum provided with heating devices, treated with hydrogen chloride for 1 to 2 h at 120° to 130°C and then neutralized with ammonium vapor at 80 to 100° for 15 to 20 min.

Krivunchenko, N.G. Kolkhir, K.F. Zvereva, N.I. Dmitrieva. E.V. Drugovskaya, M.N. and Sokolov, S.A. Gas tars in reclaiming rubber. Kauchuk i Rezina. 21 (1): 52-3 (1962) (R.A., 41:67).

Krivunchenko, N.G., Kolkhir, K.F., Zvereva, N.I. Dmitrieva, E.V. and Sokolov, S.A. Reclaim of rubber. U.S.S.R. Pat. 138,022 (May 10, 1961); Byul. Ixobret. 1961 (9), 42-3. (R.A., 39:436). Gas Generator Resin.

Kuznetson, V.I., Govorova, R.P., Kivyi, G.V. and Landa, I.M. Use of the furfurol extract of the ligroin-petroleum fraction of primary lignite tar for rubber reclaiming. Ukrain. Khim, Shur., 21: pp. 12731 (1955) (C.A., 49:16496; R.A. 34:61). Lignite tar.

Lambrino, V. Norsene, M. and Verodi, F. Reclaiming of used rubber by means of D.T. plasticizer with swelling properties. Ind. Usoara (Bucharest), 5: pp. 56-59 (1958). (R.A., 36:258). A new plasticizer containing maphthenic, paraffinic, aromatic and unsaturated hydrocarbons.

LeBeau, D.S. U.S.P. 3, 184, 422 (1965) Retardation of Mooney growth with 3 parts of Sodium Nitrite.

LeBeau, D.S. Reclaiming agents for natural and synthetic rubber. I. Solvent naptha. R.A. (N.Y.), 68: pp. 49-56 (1950). (C.A., 45:1372; S.C.L., 28:398,966).

LeBeau, R.V. Reclaiming synthetic rubber with (1) an amine and (2) a fatty acid and live steam. U.S. Pats. 2,423,032 and 2,423,033 (June 24, 1947). (C.A., 41:6074; S.C.L., 25:699).

Levin, M. Method of making rubber mixtures and resulting product U.S. Pat. 2,261,166 (Nov. 4, 1941). Heating fiber-containing scrap with a small proportion of a mild alkali.

Lewis, J.R. Reclamation of rubber in the presence of a, a-di-alkylarylmethyl hydroperoxide. U.S. Pat. 2,558,764 (July 10, 1951). (To Hercules Powder Co.). (S.C.L., 29:765).

Liverovskii, A.A., Shrulevskaya, E.I. and Sokolov, S.A. Substitutes for crude pine resin in the reclaiming industry. Zhur. Priklad, Khim., 30: pp. 1837-43 (1957). (C.A., 52:10628; R.A., 36:454). Rosin obtained from pine stumps.

Lorand, E.J. and Reese, J.E. Oxidation of aromatic hydrocarbons U.S. Pat. 2,548,435 (Apr. 10, 1951). (To Hercules Powder Co.). (C.A., 45:8555; S.C.L., 29:1009). Useful in rubber reclaiming.

Mankowich, I. Reclaiming of vulcanized scrap rubber. U.S. Pat. 2,871,205 (Jan. 27, 1959). (To U.S. Rubber). Treating with formaldehyde.

Mankowich, I., Steinle, L.E. and Chiavetta, F.P.U.S. Pat. 2,871,206 (Jan. 27, 1959). (C.A. 58:10828; R.A. 37:375). (To U.S. Rubber) Adding aldehyde to the reactants in the heater process.

Metallgesllschaft, A.-G. Treatment and regeneration of rubber hydrocarbons. French patent 877,891. (S.C.L., 23:463; Rev. Gen. Caout., 20:20) By-products of acid tars used.

Mersereau, J.M. Mester P.J. USP 3267067 Retardation of Mooney growth by the addition of benzyl mercaptan.

Midland Silicones, Ltd. Reclaiming siloxane elastomers Brit. Pat. 752,860 (July 18, 1956). (R.A., 34:502). Anhydrous hydrogen chloride.

Mishustin, I.U., and Pisarenko, A.P. Influence of softening agents on the reclaiming of soiling waste. Kauchuk i Rezina, No. 1: pp. 42-43 (1941). (C.A., 37:5621; Chem. Zentr., 113: Part II, 1064).

Montecatini Soc. Gen. F.P. 1429092 Regeneration of Elastomers based saturated vulcanized olefin copolymers. Polymers heated to 175-225°C, 2-10 hours.

Moore, D.V., and Thompson, H.H. Reclaiming method. Can. Pat. 429,743 (Aug. 28, 1945) and U.S. Pat. 2,386,707 (Oct. 9, 1945). (To Wingfoot Corp.). (C.A., 39:512; 40:763). Reclaiming a cured butadiene copolymer with styrene or acrylonitirile by heating with a swelling agent which contains ethyl alcohol as a plasticizer.

Morche K. Ehrend H. Rev. Gen. Caout Plast., 43, no. 9 Sept. 66 p. 1111-15. Use of factice in ethylene propylene terpolymers.

Naftolen Gesellschaft zur Veruwertung der Rostler-Mener'schen Verfahren, MbH. Regeneration of vulcanized rubber. Netherlands Pat. 55,743. (S.C.L., 23:235; Rev. Gen. Caout., 21:26). Heating between 160° and 380°C., under a pressure of 12 mm. of mercury in the presence of resinous substances or of oils, soluble to at least 30% in concentrated sulfuric acid.

Naphthenic acids in the rubber industry. Rev. Gen. Caout., p. vi. Supplt., June 1936, (S.C.L., 14:591).

Naudain, E.A., and Boys, C.H. Pan process of reclaiming rubber U.S. Pat. 2,794,006 (May 28, 1957). (To Hercules Powder Co.). (C.A., 51:12534; R.A., 36:15). Petroleum hydrocarbon-insoluble pine wood resin.

Neal, A.M., and Schaeffer, J.R. Devulcanizing Rubber. U.S. Pat. 2,333,810 (Nov. 9, 1943). (To DuPont). Subjection whole-tire scrap separately to the action of a thiophenol and to dilute aqueous sodium hydroxide. Can. pat. 423,928.

Nicholaisen, B.H. Vulcanized rubber reclaiming composition of sulfurized tall oil and napthernic base petroleum oil. U.S. Pat. 3,008,906 (Nov. 14, 1961). (To O. Mathieson Chem. Corp.) (C.A., 56:6144: R.A., 40:298).

Nikolaev, N.V. Mikhailov, N.I. and Yastrebov, T.G. Softener for regeneration of rubber. Russian Pat. 105,203 (March 25, 1957). (C.A., 51:10111; R.A., 35:475).

Oblocynzsky, J. Reclaiming vulcanized synthetic rubber waste. French Pat. 931,885. (S.C.L., 27:686; Rev. Gen. Caout, 26:531). Pretreating with paraffin oil.

Oils used in reclaiming rubber. Oil, Paint & Drug Reptr., 142: No. 15, p. 44 (Oct. 12, 1942).

Osipovsky, B.Y., Khutoretskaya, S.N., Borscheveskaya, V.A. and Khrenkov, I.I. Rubber reclaiming process. Russian Pat. 58,383 (S.C.L., 23:306; Rev. Gen. Caout., 20:6). Using a fraction of tar oil as solvent.

Osipovskii, B. Ya., Knutoretzkaya, S.N. Borschchevskaya, V. A. and Khrenkov, I.I. Reclaiming rubber. Russian Pat. 58,836. (C.A., 39:1080; S.C.L., 20:215; Chem. Zentr., 112:II,824). Use of boiling tar oil.

Patel M.U. Rubber News, 6, no. 10, July 67, p. 22. Resins in the Rubber Industry. Resins, their makers their effects on rubber properties structures etc are discussed.

Pearson, W.L., and Schweller, H.E. Reclaiming of uncured and uncompounded latex foam stock. U.S. Pat. 2,925,396 (Feb. 16, 1960). (To General Motors). (R.A., 38:431; C.A., 54:11534). Use of mineral acid.

Phoenix Gummiwerke AG GP 1233132 Vulcanized Rubber Waste. Pretreated with diazonium salt. Azo dyes form which do not migrate to give non stain reclaim.

Polyplast Gesellschaft Fur Kautschukchemi. Platiciation of rubber waste. German Pat. 1,000,598 (Jan. 10, 1967). (R.A., 38:221; C.A., 53:23048). Use of triethylamine oleate.

Polyplast Gesellschaft Fur Kautschukchemi m.b.H. Regeneration of scrap rubber. Brit. Pat. 761,478 (Nov. 14, 1956). (R.A., 35:114). Balata and gutta-percha is reclaimed by mixing with an oxidized extract of a mineral lubricating oil.

Proell, W.A. Thiosulfenyl chlorides and bromides, and polymers made therefrom, U.S. pat. 2,684,952 (July 27, 1954). (To Standard Oil Co.). (R.A., 33:73). Polysulfide rubbers reclaimed by reacting with chlorine.

Radinger, E.J. Treatment of reclaimed rubber. Brit. Pat. 712,827 (Aug. 4, 1954). (To Thames Industries, Ltd.).

(R.A., 32:491). Addition of ammonia to emulsions of reclaim.

Randall, R.L. Reclaiming scrap. U.S. Pats. 2,545,828 and 2,471,496 (March 20, 1951). (To Midwest Rubber Reclaiming Co.). (C.A., 43:6438; S.C.L., 29:488) Gray Tower resin oil.

Ray, P.A. Treatment of rubber. Brit. Pat. 546,797 (July 30, 1942). (To Hercules Powder). (C.A., 37:4930; S.C.L. 20:347). With a softener comprising a blend of an oily product from destruction distillation of pine-wood resin and the residue of such distillation.

Reagents used in manufacture of vulcanizing agents; solvents for reclaiming vulcanized rubber scrap; solvents, general, for rubber. Oil, Paint & Drug. Reptr., 142: No. 3, p. 44 (July 20, 1942). Alphabetical lists.

Rebmann, A. Regeneration of aged rubber. Swiss Pat. 215,952 (Nov. 1, 1944) (C.A. 42:4390; S.C.L. 23:235; Rev. Gen. Caout., 21:26). Treating under pressure with benzene substitution products containing thiophenol, and washing thereafter with water, oil or glycerin.

Regie Nationale Des Usines Renault. Utilizing reclaimed rubber. French Pat. 952,734. (C.A., 45:5446; S.C.L., 28:303; Rev. Gen. Caout., 27:175); Lead salt of a derivative of dithiocarbamic acid.

Reich, HFH Increasing the output of comminuting machines for viscous and elastic scrap material. German Pat. 892,676 (Aug. 27, 1953). (To Gebruder Eirich). (R.A., 32:268). Material treated first with a swelling agent.

Rennemann, H., and Gunzert, T. Reclaiming vulcanized synthetic rubber scrap. German Pat. 716,151 (Dec. 11, 1941). (C.A., 38:2524). Using a softener which is a combination of three softeners, E.G., tetrahydronaphthalene, coumarone resin, and wool fat.

Rhein-Chemi GmbH. Waste vulcanized rubber. Ger. Pat. 1,123,102 (Feb. 1, 1926; Ger. Pat. Abstr. 2 (9), 1 (1962) (C.A., 56:14447; R.A., 40:236). Comminuted waste is mixed with salts or heavy metal salts of fatty acids or mixtures of such salts, and the mixture is heated above 100°C.

Rivier, A., and Dietzel, E. Working-up scrap rubber. German Pat. 8395 (Oct. 11, 1954). (To Deutsches Hydrierwerk Rodleben, V.E.B.) (R.A., 34:62) Working-up is carried out with swelling agents.

Rostler, K.S., and White, R.M. Swelling of rubber. I. Study of aromatic hydrocarbon reclaiming oils with regard to swelling action of GR-S and natural rubber. R.A. (N.Y.), 58: pp. 585-90 (1946). (C.A., 40:2671; S.C.L., 24:257).

Rubber Reclaiming Co. B.P. 1009592. Recovery of nylon from tyre scrap. Using 60-75% aqueous formic acid.

Sakada, M. Reclaimed rubber. Japanese Pat. 176,629 (Aug. 31, 1948). (C.A. 45:4962; S.C.L., 29:661). With furfural.

Sanyou Yushi Kogyo Co. and Teikoku Kasei Co. Process for the treatment of reclaimed rubber. Japan Pat. 15,381 (1961). (R.A., 40:293). A non-ionic surface activator is used.

Sarada, M. Regenerated rubber. Japanese Pat. 177,783 (Feb. 15, 1949). (C.A., 45:9910; 30:110). Mixed with waste liquor from sulfite pulp.

Sartorelli, U. Reclaiming vulcanized rubber. East German Pat. 509 (Nov. 30, 1953) (To Pirelli Societa per Azioni). (R.A., 33:430). Aliphatic alcohols.

Satake, S., and Tatebayashi, K. Regeneration of vulcanized rubber scrap. Japanese Pat. 3746/1950 (Oct. 27, 1950). (To Furukawa-Industries Co.). (C.A., 46:10677-78; R.A., 31:67). Dibenzyl Ether.

Saul, W., and Wiggins, T.J. Reclaiming of rubber. Brit. Pat. 744,917 (Feb. 15, 1956). (To Semtex, Ltd.). (R.A., 34:236). Polyglycol esters of monobasic organic acids.

Schneider, P. Mastication and reclaiming with chemical agents. (Abstracts only). Kautschuk and Gummi, 4: p. 407 (1951); Gummi u. Asbest. 4: p 392 (1951). (R.A., 30:68). Aromatic mercaptans and disulfides.

Schwerdetel, F. Reclaiming vulcanized rubber. German Pat. 737,948 (July 1, 1949) (To W.G. Farbenindustrie). (C.A., 39:4150). By subjecting scrap to an oxidizing treatment in the presence of a chloronitrobenzene.

Semperit Gummiwerk G.P. 1218715 Reclaimed Rubber. Pretreat rubber with aldehydes in presence of dil H_2SO_4. This type can be used in contact with white or light-colored PVC without discoloration.

Shokhin, I.A., and Belostotskaya, G.I. Molecular structure of the rubber in reclaim. Trudy Nauch. Issledovatel. Inst. Resin. Prom., No. 2 pp. 136-45 (1955). (R.A., 34:533). Trichlorothiophenol is a good activator.

Smith, G.E.P., Jr., and Ambelang, J.C. Reclaimed rubber. U.S. Pat. 2,495,145 (Jan. 17, 1950). (To Firestone). (C.A., 44:3293; S.C.L., 28:370). With reaction product of sulfur dichloride and a phenol.

Smith, G.E.P., Jr. and Bennett, R.B. Reclaiming rubbers. U.S. Pat. 2,686,163 (Aug. 10, 1954). (To Firestone). (R.A., 33:73). Aliphatic amines.

Smith, G.E.P., Jr. Reclaiming rubbers. U.S. Pat. 2,626,932 (Jan. 27, 1953). (To Firestone). (C.A., 47:4642; R.A., 31:306). Sulfide of a petroleum cresylic acid.

Sokolov, S.A., and Drozdovskii, V.F. Influence of the composition of pine tars of reclaiming tire stock from natural and synthetic rubber. Kauchuk i Rezina, 16: No. 9, pp. 12-15 (1957). (C.A., 52:10627; R.A., 36:160). Pine tars as softeners for rubber reclaim.

Sparks, W.J. and Baldeshwieler, E.L. Recovery of isoolefin polymers. U.S. Pat. 2,343,816 (March 7, 1944). (To Jasco, Inc.) (C.A., 38:3395). Isolating pure isobutylene polymers from a vulcanized composition with natural rubber by extracting with naptha hydrocarbons.

Spcoete, A. Wolber, Reclaiming synthetic rubber. French Pat. 925,088 (1948). (S.C.L., 26:900; Rev. Gen. Caout., 25:94). Reduced to dust and treated with coal tar anthracene oil or coumarone resins.

Stafford, W.E., Mellor, G. and Armstead, B.H. Soluble zinc sulfide in reclaim. Rubber Plastics Weekly 141 (4), 119-20 (1961). (R.A., 39:485).

Standard Oil Co. of N.J. Petroleum Products for Rubber (Technical Bulletin). R.A. (N.Y., 45: p. 31 (Apr., 1939); I.R.W., 100: No. 2, p. 63 (May, 1939).

Staten, F.W., and Haines, W.M., Jr. Reclaiming mixed vulcanizates of natural and synthetic polymers. U.S. Pat. 2,522,069 (Sept. 12, 1950). (To Gates Rubber Co.). (C.A., 45:384; S.C.L., 28:890). With multivalent catalyst.

Studio Chmico Industriale, Depolymerication of vulcanized rubber. Italian Pat. 451,123 (Aug. 27, 1949). (Also Italian Pat. 431,570). (C.A., 43:8734; 45:896; S.C.L., 29:386). Napthalene.

Sugimoto, S. Minamikata, I., and Sakai, K. Studies of reclaimed rubber. I. Alkali-reclaimed rubber. Repts. Imp. Ind. Research Inst., Osaka, Japan 20: No. 10,41 pp. (1940). (C.A., 35:929). III. Oil reclaimed rubber. Ibid, 21: No. 5, 28 pp. (1940). (C.A., 35:929. Use soybean oil.

Sugino, K. Softeners for miscellaneous types of reclaim. J. Soc. Rubber Ind. Japan, 16: pp. 79-90 (1943). (C.A., 43:8191; S.C.L., 28:51).

Sverdrup, E.F. Reclaiming vulcanized rubber in the presence of unvulcanized high styrene polymeric material U.S. Pat. 2,845,395 (July 29, 1958). (To U.S. Rubber Reclaiming Co.). (C.A., 52:19230; R.A., 37:66). Natural GR-S, nitrile and butyl rubber can be reclaimed.

Sverdrup, E.F. Reclaiming rubber. Brit. Pat. 675,595 (July 16, 1952. (To U.S. Rubber Reclaiming Co., Inc.). (R.A., 30:416). A compound with the thiophene ring.

Sverdrup, E.F. Reclaiming rubber with thiophene compound. U.S. Pat. 2,494,593 (Jan. 17. 1950). (To U.S. Rubber Reclaiming). (C.A., 44:3737; S.C.L., 28:268).

Swellers for rubber in reclaiming processes. Oil, Paint & Drug Reptr., 142: No. 16, p. 71 I Oct. 19, 1942). Alphabetical list.

Syui-Chzhou, Li. Comparative study of the use of pine resin and hemp seed oil for the preparation of reclaim for shoe soiling. Khuasyue Shintsze, No. 12, pp. 540-42 (1957). (R.A., 37:66). Hemp seed oil.

Tewksbury, L.B. Jr., and Howland L.H. Reclaiming with hydrocarbon disulfide. U.S. Pat. 2,469,529 (May 10, 1949) and British Pat. 622,576 (To U.S. Rubber) C.A., 43:5992; S.C.L., 27:603).

Thompson, H.H. Depigmentizing reclaimed rubber. U.S. Pat. 2,365,662 (Dec. 26, 1944). (To Wingfoot Corp.). (C.A. 39:3968; S.C.L., 23:150). Mixing bententie with the stock and the extracting with a rubber solvent while the benton inhibits removal of the carbon black by the solvent.

Treves, A. Process of reclaiming rubber waste materials. U.S. Pat. 2,325,289 (July 27, 1932). (C.A., 38:660). Heating ground rubber scrap and 1 to 5% of abietic acid or sylvic acid in the absence of water or steam for 30 minutes at 100-140°C.

Treves, A. Process for the treatment of rubber waste. U.S. Pat. 2,352,460 (June 27, 1944). (C.A. 38:5692; S.C.L., 22:303). Rubber reclaim which is soluble in rubber solvents by treatment of ground vulcanized scrap with abietic acid or sylvic acid.

Treves, A. Treatment of rubber and particularly rubber waste materials. Brit. Pat. 551,461 (Feb. 24, 1943). (C.A., 38:2850; S.C.L., 21:112). Mixing not more than 10% of abietic acid or abietic acid-containing substances or coumarone resin into ground scrap and heating for 1 to 2 hours only at a temperature not exceeding 180°C.

Tsi-Te, Ku, Investigation of the use of pine tar resin in the reclaim of synthetic and natural rubber. Hsiang-Tsiao, No. 6, pp. 15-21 (1959) (R.A., 38:520).

Tsvetaeva E.M. New Reclaiming Agents based on chemically treated shale Sov. Rbb. Tech. vol. 25, no. 9, p 42 (1966) Phenolic pitch has a reinforcing effect on reclaim.

Tsvetaeva, E.M. Methods of synthesis and modification of softeners for reclaiming vulc. anisates. Vol. 24 No. 11 Page 19 Nov. 1965 Len. 4 Lang Rus. Kauchuk, I. Rezina.

Tsvetaeva, E.M. Role of softeners in the reclaiming of vulcanizates from SK-B. Legkaya Prom., No. 6: pp. 25-26 (1944). (C.A., 39:4515). Softeners must act as swelling agents and penetrants, have high adhesive properties, and be capable of further polymerization or vulcanization: those having multiple unsaturated bonds in the same carbon chain, i.e., highly unsaturated aliphatic acid derivatives.

Tsvetaeva, E.M. Kauch i Rezina 26, no. 6, June 1967, p 37. Reclaiming of SKD vulcanizates (Stereoregular butadiene rubber) reclaimed with fatty acid, plasticizer and shale-oil.

Tsvetaeva, E.M. Glushnev V.E. Method of Synthesis and Modification of Softeners for Reclaiming Vulcanizates. Sov. Rubb Tech. vol.24, no. 11, p 200 (1965).

Tsvetaeva, E.M. Reclaiming of vulcanized rubber. Russian Pat. 125,380 (Jan. 8, 1960). (R.A., 38:327; C.A., 54:12640). Propane and hexane used.

Utanol – A. Semi-Softening Agent, R.A. (N.Y.) 43: p. 228 (July 1938). S.C.L., 16:810).

Van Valkenburgh, E.A. Liquid for reclaiming rubber. U.S. Pat. 2,736,662 (Feb. 28, 1956). (C.A., 50:8243; R.A., 34:433). Tall oil.

Van Valkenburgh, E.A. Reclaiming oil composition and method of making it. U.S. Pat. 2,908,676 (Oct. 13, 1959). (R.A., 38:221; C.A., 54:1915). Relates to Bunac KS.

Van Valkenburgh, E.A. Solvent for reclaiming vulcanized rubber. U.S. Pat. 2,714,071 (July 26, 1955). (C.A., 50:4548; R.A., 34:108). Diethylene Triamine.

Vinitskii, L.E., and Litovchenko, M.P. Thermal reclaiming of natural rubber in the presence of activators. Trudy vseros, Nauchoissled. Khim. Inst. Prom. Mestn. Poschinen - iyz, No. 6, pp. 45-52 (1958). R.A., 37:482). Trich'oroph - enol.

Warren, S.F., and U.S. Rubber Reclaiming Co., Inc. Reclaiming natural and synthetic rubber. British Pat. 610,901 (S.C.L., 27:158). Organic disulfide.

Warren, S.F. Reclaiming rubber. Brit. Pat. 657,637 (Sept. 26, 1951). (To U.S. Rubber reclaiming Co., Inc.) (R.A., 30:13). Tertiary lauryl mercaptan.

Webb, E.J., Cook, W.S., Albert, H.E., and Smith G.E.P., Jr. Arylamide sulfide cayalysts in reclaiming GR-S vulcan - izates, Ind. Eng. Chem., 46: pp. 1711-15 (1954). (C.A., 48:14281; R.A., 32:510).

Westhead, J. Fillers for reclaim stocks. Trans. Inst. Rubber Ind., 17: pp. 249-54 (Feb. 1942). (C.A., 36:5675). Dis - cusses effect of pigments.

Wheeler, G.P. Reclaimed rubber and method of making same. U.S. Pat. 2,433,179 (Dec. 23, 1947). (To Goodrich). (C.A , 42:2468; S.C.L., 26:213). An aryl selenide used.

White, C.M. Oxidized tall oil and petroleum oil composition method of making and method of reclaiming rubber. U.S. Pat. 3,043,786 (July 10, 1962). (C.A., 57:10015; R.A., 41:107). A small amount (0.5 to 2.5% by weight) of tall oil oxidized as described is added to rubber being reclaimed. An example describes the reclamation of SBR.

White R.A. USP 3210301 Process of Reclaiming Rubber wherein Atactic Polypropylene is added.

Wingfoot Corp., Reclaiming synthetics. Brit. Pat. 558,334 (Dec. 31, 1943). (C.A., 39:3966; I.R.J., 106:381). By treating hot with a swelling agent, and incorporating a carboxylic acid or a monohydric aliphatic alcohol into the swollen material.

Wingfoot Corp. Regenerating copolymers. British Pat. 615,865. (C.A., 45:1378; S.C.L. 27:324). Mix rubber with coal tar distillate and heat.

Yaroslay, C. Reclaiming of synthetics from polymers of butadiene and the alkyl or halogen drivatives of rubber. German Pat. 743,605 (Dec. 29,1943). (Chem. Zentr. 115: Part I, 1047). By treating under heat and pressure with compounds containing dithiocarbomic acid derivatives, thiazole, thiuram sulfide, thiazoyl disulfide or benzo-thiazoyl disulfide.

Zachesova, G.N. Yablonskya, F.A. Kauch i Rezina, 26, no. 8 Aug. 67 p. 39 Wood chemistry products as emulsifiers in the reclaiming of rubbers by the dispersion method. Rosins and tall oil emulsifiers are evaluated.

Zaionchkovskii, A.D., and Livyi, G.V. Destruction of rubber materials in reclaim manufacture. Legkaya Prom., No. 9, p. 34 (1955). (C.A., 50:5322; R.A. 34:279). Destruction is accelerated by oxidants.

Refining/Finishing Equipment

Baratteri, A. Apparatus for refining reclaimed rubber.

Italian Pat. 393,128 (Kautschuk, P. 70, Oct.–Nov. 1943).

Brown, G.L., and Johnson, T.A. Finishing reclaimed rub - ber. Brit. Pat. 703,087 (Jan. 27, 1954) and U.S. Pat. 2,645,817 (July 21, 1953). (To Wingfoot Corp.). (R.A., 32:199). Final plasticization and sheeting steps.

Campbell, C.H. Refining reclaimed rubber with cooling of the rubber to facilitate separation of tailings. U.S. Pat. 2,471,392 (May 24, 1949). (S.C.L., 27:689).

Campbell, C.H. Refining of reclaimed rubber. U.S. Pat. 2,524,375 (Oct. 3, 1950). (S.C.L., 28:965).

Gordinskii, B.Y., Shimanskii, V.M., Gaevskii, A.F., Shkol - nik, S.I. Reworking of polyester urethane Plasticheskie Massy Vol. No. 9 Page 65 Sept. 1965 Len. 2 Lang. Rus.

Hayakawa Rubber Co. Apparatus for automatically refining desulfurized reclaim rubber. Japanese Pat. 6,441, (1959). (R.A., 38:112).

Jarvis, E.A., Refining scrap plastic and apparatus therefor. U.S. Pat. 2,879,005 (March 24, 1959). (To M. Sobel). (C.A., 53:1184; R.A. 37:504). PVC, polyethylene, and SBR.

Rivier, A. and Dietzel, E. Working-up of scrap rubber German Pat. 8395 (Oct. 11, 1954). (To Deutsches Hydrier - werk Rodleben V.E.B.) (R.A., 34:62) Working-up is carried out with swelling agents.

Retreaders

Braner, H.H., An Analysis of the Domestic Retreading Industry, Ranno Printing Co., Englewood, N.J., Lib. Con - gress#65-5620.

Corey, E.R. Industrial Marketing; Cases and Concepts. Englewood Cliffs, N.J.: Prentice Hall, Inc. 1962.

Schidrowitz, P., and Dawson, T. (eds.) History of the Rubber Industry, Cambridge: W. Heffer & Sons Ltd., 1952.

Articles and Periodicals

"Cheap Materials Can Damage Reputation of Retread Business," NTDRA Dealer News, XXVII, No. 40, p. 2.

(Edwards, George). "Adjustment Costs, Policies and Objectives," Retreaders Journal (September, 1962), p. 7.

(Edwards, George). "Adjustment Policies," Retreaders Journal (August, 1962), p. 14.

"Inconsistency is Causing Tread Separations," Retreaders Journal (June, 1963), P. 18.

"New SBA Guarantee on Equipment Financing May Boost Retreading," Retreaders Journal (May, 1964), p. 3.

"H.R. 10712 – Federal Legislation," NTDRA Dealer News, XXVII, No. 15 (April 20, 1964), p. 2.

"How Retreaders Advertise," Retreadweek, II, No. 1 (April, 1963), p. 15.

"Interesting Facts About Retreaders," Retreadweek, III, No. 1, (April, 1964) p. 57.

Janicki, E. "Automakers Comment on [illegible] Standards," NTDRA Dealer News, XXVII, No. 17 (April 27, 1964), p. 5.

Murphy, J.S. "Jet to Spark Room in Treading," Tires and TBA Merchandising (August, 1957), p. 29.

"Quality is Avenue to Take," Retreadweek, II, No. 1 (April, 1963), p. 34.

"Quality Merchandising of Quality Retreads," NTDRA Dealer News, XXVI, No. 46 (November 11, 1963), p. 8ff.

"Recapper Profits from Quality Market," Tires and TBA Merchandising (November, 1961), p. 32.

Baylor, Ivan. "Economy Tires Dim Your Profit Picture," Modern Tire Dealer (November, 1962), p. 53.

"Tire Inspection Rules, Regulations Passed," NTDRA Dealer News, XXVII, No. 34 (August 24, 1964), p. 3.

Reports and Surveys

Crowell-Collier Automotive Survey. An Annual Survey Performed by Crowell-Collier Publishing Co., New York, N.Y.

Look National Automobile and Tire Survey. An Annual Survey Performed by Cowles Magazine and Broadcasting Co., New York, N.Y.

National Tire Dealers and Retreaders Association, Estimates of Tire Replacement Shipments by Channels of Distribution and Tire Types: 1957-1962 (By Dr. Warren Leigh), Washington, D.C., 1963.

NTDRA Merchandising and Advertising Catalogue, Washington, D.C., 1962.

Repair and Retreading Service for Off-the-Round Tires: National Directory, Washington, D.C., 1962.

Retread Shop Operating Manual, Washington, D.C., 1962.

Newsweek Passenger Tire Census. Annual Survey performed by Newsweek, Inc., New York, N.Y.

Newsweek Truck Tire Census. An Annual Survey performed by Newsweek Inc., New York, N.Y.

Rubber Manufacture Association. RMA Recommended Minimum Standards for New Passenger Car Tires, New York, 1964.

Rubber Highlights, New York, N.Y. (Monthly).

Special Survey of Tire Production Capacity, New York, N.Y. 1963.

Tire Retreading Institute (Division of National Tire Dealers and Retreaders Association). National Standards for Treading Automobile and Truck Tires. Washington, D.C., 1959.

Sales Pamphlets and Literature

An Analysis of the Automotive Market, New York: Tire, Battery and Accessory News, 1958.

Retreading Equipment: Catalogue No. 1, Lodi, Calif.: Super Mold Corporation, 1962-1963.

Rubber in Roads

Accumulatoven-Fabrik, A.G.,
Reclaim, French Pat. 876-353; (Rev. Gen. Caout., 20:6) Immersing Scrap rubber in hot bitumen at 230°-250° for a period between 15 to 30 minutes in the absence of air.
Reclaimed Rubber, Ital. Patent 393,309. Dipping in hot Bitumen.

Allison, K.
Those Amazing Rubber Roads, Rubber World, pp. 47-52 March 1967.

Those Amazing Rubber Roads, Part II Rubber World, pp. 91-106, April 1967.

Andeyeri, J.B.,
Schiffman, R.L.
Pavement Design Methods – Literature Review, Bureau of Public Roads, March 1965 (480 References)

The Asphalt Institute

Asphalt Membranes and Expansive Soils, The Asphalt Institute Information Series, No. 145, May 1968.

Benson, J.R.

The Reology of Rubberized Asphalts Annual Meeting Paper, Assoc. of Asphalt Paving Tech., Feb. 1-3, 1954.

Rubber in Today's Bituminous Road Construction, Western Construction Vol. 29, No. 9, 10 Sept. 1954, pp. 61-3.

Rubberized Asphalt. Western Construction Vol. 34, No. 7, p. 68, July 1959. Rubberized Roads in Colorado.

Bernhard, R.H.

Bibliography on Soil Dynamics, Special Report 89, U.S. Army Material Command, Cold Regions, Research and Engineering Laboratory, Hanover, New Hampshire, Sept. 1965 (1223 References).

Characteristics of Bituminous Materials, Highway Research Board Bibliography, 35, National Research Council, Washington, D.C., 1963 (750 References).

Characteristics of Bituminous Materials, Highway Research Board Bibliography, 40, National Research Council, Washington, D.C., 1966, (370 References).

Chuzo, Itakura,
Teruo, Sugawara

Some characteristics of Rubber Blended Asphalt and Its Mixtures at Low Temperatures. Proc. of AAPT, Vol. 28, 1959, pp. 385-412.

Clinebell, B.J. and
Straka, L.E.

Survey on Use of Rubber in Bituminous Pavements. Rubber Age, Vol. 70, No. 1 Oct. 1951, p. 69-71.

Cormac, P.B.

Rubber-Latex. Cement Compositions. Rubber Dev., vol. 8, No. 2, p. 46-52 Summer 1955.

Decker and
Nijveld

The Influence of Rubber Additions on Some Mechanical Properties of Asphaltic Bitumens. Paper, Third World Petroleum Congress, 1951.

Determination of Rubber Content by Iodine Value and Specific Viscosity Measurements. Road Research Laboratory, Road Note No. 36.

Dowd, M.E.

Rubber Tested in Bituminous Roads, Better Roads, Vol. 20, No. 1, Jan. 1950, p. 31-3.

Dussek, A.E.H.

What is Rubber Road? Rubber Age and Synthetics, Vol. 32, No. 5, July 1951, p. 158-60.

Combining Rubber and Asphalt for Road Paving, Roads and Engr. Construction Vol. 89, No. 12 Dec. 1951, p. 86-7, 122-4.

Endres, H.A.

(Burr, W.W.) Method and Apparatus for Adding Latex to Hot Bitumen. U.S. Pat. 3,127,367 (31 Mar. 1964) (To Goodyear) Non foaming latex addition to pug mill.

(Coleman, R.J.) (Pierson R.M., and Sinclair, E.A. Effects of Synthetic Elastomers on Properties of Petroleum Asphalts, Ind. and Engr. Chem., vol. 43, No. 2, 1951.

Flexible Paving Composition U.S. Pat. 3,253,521 (31 May 1966) (To Goodyear) Particulated rubber and bitumen are molded.

(Pullar, H.B.) Process of Preparing Rubberized Compositions. U.S. Pat. 3,202,623 (24 Aug. 1965) (To Goodyear) Hard asphalt and rubber are coprecipitated.

(Shaw, J.W., Jr.) Rubber Barytes Compositions and Methods of Preparations (To Goodyear) U.S. Pat. 2,809,179, 8 Oct. 1957. A water suspension of barytes and rubber latex is dried and powdered and added to the asphalt.

(Shaw, J.W., Jr.) Rubber Compositions U.S. Pat. 2,700,655 (25 Jan. 1955) (To Wingfoot) Latex and filler are dried, powdered and added to bitumen.

(Winters, W.F.,) Rubberized Mineral-Tar Composition and Process of Making Same U.S. Pat. 2,921,919 (19 Jan. 1960) (To Goodyear) Nitrile Rubber-Barytes Added to the Pug Mill.

Experimental Work on Rubberized Asphalt Surfacing, Commonwealth Engineer, 1 Sept. 1951, Highway Research Abstract, Feb. 1952.

Feigle, F.

Chemistry of Specific Selective, and Sensitive Reactions, Academic Press, New York, 1949.

Firestone, H.S.

Rubber Roads have proved safer, less costly. Rub. Dev. Vol. 5, No. 1, Spring 1952, p. 20-1.

Fisher, H.K.

Development and Use of Rubber in Bituminous Pavements, India Rubber World. Vol. 127, No. 2, Nov. 1952, p. 220-2.

Natural Rubber Powder in Roads. Rub. Dev. Vol. 2, No. 4, Dec. 1949, p. 10-2.

Report on Use of Rubber in Bituminous Pavements, Public Works, Vol. 85, No. 11, Nov. 1954, p. 73-6.

FLO-MIX

U.S. Rubber Reclaiming Co. Inc. (Joint and Crack Sealer) Public Works, Aug. 68 (Adver.)

Frolova, M.K.
Studennikov, V.A.
The Influence of Vulcanizing and Stabilizing Agents on the properties of Bitumen-Rubber Coatings. Kauchuk i Rezina, 27 (2):44. February 1968. Bitumen-chloroprene.

Galloway, B.M., et al
A Long Range plan for Engineering Research on Flexible Pavements, Defense Documentation Center, AD-648-572, Nov. 1966. (362 References).

Ghez, H.,
Ghez, O.,
Caoutchouc regeneration, U.S. Pat. 2,296,275, (C.A., 37:1298). By heating in a liquid bath of bituminous material at 180° to 225°C until it can be readily plasticized by milling.

Goodyear Tire & Rubber Co.
U.S. Pat. 3253521: Flexible Paving Composition. Particulated rubber is added to molten bitumen.

Gregg, L.E.,
Alcoke, W.H.
Investigations of Rubber Additives in Asphalt Paving Mixtures. Properties and Test Methods. Cooperative Sponsorship: Firestone Tire and Rubber Co., Univ. of Kentucky, College of Engineering.

Investigation of Rubber Additives in Asphalt Paving Mixtures AAPT Proc., Vol. 23, 1954, pp. 28-63.

Additional Observation on the Use of Rubber in Bituminous Paving Mixtures. A.R.B.A. Tech. Bull. No. 194, 1953.

Investigations of Rubber Additives in Asphalt Paving Mixtures. Proc. Assn. of Asph. Pav. Tech., vol., 23, pp. 28-63 (1954).

What is desired from the use of rubber in bituminous paving mixtures, A.R.B.A. Tech. Bull. No. 179, 1951.

Griffin, R.L., et al
Microfilm Durability Test for Asphalts. Shell Development Company, Emeryville, California.

Grubb, P.E.
An Experiment in Beach Sand Stabilization. Public Works June 69 p. 83-84 Bentonite, Portland using sand aggregate.

Gundermann, E.
Principles of Combining Bitumen with Elastomers, Plate Kautschuk, 16 (1): 37. January 1969. Physical and chemical properties of Rubber/ Asphalt Blends.

Henniker, I.C.
Rev. Mod. Phys. 21,322 (1949) Behavior of Thin Film Liquids.

Highway Research Board Committee, MC-A5 Bibliography on Relation of Physical Characteristics of Bituminous Mixtures to Performance of Bituminous Pavements, July 1966, (144 References).

Hoiberg, A.J.
Garris, W.E., Jr., Analytical Fractions of Asphalt, Analytical Edition, Ind. and Engr. Chem., May, 1944.

Hosek, J.
Polymer Modified Cement Montors, J. Amer. Concrete Inst. Dec. 1966.

Horowitz, S.I.
Kufrin, R.J.
A new polymer bitumen composition Amerc. Chem. Soc. Div. Petrol Chem. Preprints, 13 (4):C 102 Sept. 68 Rubber content 1 to 99%.

Hugg, J.K.,
Paving Composition Containing Synthetic Rubber Polymer. U.S. Pat. 2,868,749 (13 Jan. 1959) (To Firestone) High temperature addition of Latex.

Interrub, S.A.
Treatment of vulcanized fibrous rubber scrap French Pat. 1,046,857. Rev. Gen. Caout., 31, 666. Mixed with blown bitumens.

International Institute of Synthetic Rubber
Producers: Rubber Fragments in Petroleum Chem. and Engr. News. 26 May 1969 p. 33.

Kabun, D.A.
Rubberized Roads, Rubber Age, Oct. 1967 p. 75.

Kotlova, R.A. Cliner, S.A.
Provinteev, I.V. Determination of the Degree of Mogeneity of Rubber Bitumen Composition Based on Reclaim. Soviet Rubber Tech. No. 3, March 1967, Vol. 26, p. 45.

Labout, J.W.A.
Van Oont, W.P.
Anal. Chem. vol. 28, 1147-1150 (1956) Aging characistics of rubber in bitumen.

Anal. Chem., 28: 1147-1150 (1956).

Larew, H.G.
Flexible Pavement Design Literature Review, Virginia Council of Highway Investigation, Jan. 1957 (299 References).

Lewis, R.H.
Welborn, J.Y.
Effect of various rubbers of properties of Petroleum. Public Roads, Vol. 28, No. 4, Oct. 1954, pp. 64-69.

Mack, C.
Physical Properties of Asphalts in Thin Films, Ind. and Engr. Chem. Vol. 49, pp. 422-26 (1957).

Mason, P.,
Thrower, E.N.
Smith, L.M.
Influence of
Rubber on Brittleness and Viscosity of Bituminous Materials. J. Applied Chemistry, Vol. 7, pt. 8, Aug. 1956, p. 451-9.

McDonald, C.H.
New Patching Material Corrects Pavement Failures. Paper presented to: Highway Research Board, 45th annual meeting (Public Works, July 1966).

Nachtigall, K.
Schoon, T.G.F.
Microscopic Examinations of Rubber Dispersions in Asphalt. Kolloid Zeit. Vol. 156, No. 2, Feb. 1958, p. 122-32.

National Asphalt
Pavement Association
The Information, Storage and Retrieval System, (4217 References).

New Jersey Lays Rubberized Test Section. Better Roads, Vol. 23, No. 7, July 1953.

Nijboer, L.L.
VanDerPoll, C.
A study of vibration Phenomena in Asphaltic Road Constructions. Proc. Assoc. Asph. Pav. Tech., 22 (1953).

OVER-FLEX
Atlos Rubber Company, Inc. (Adver.) Paving Process for Repair of Cracked Highway.

Parker, W.D.
Walker, WDC
Rubberized Bituminous materials and their use in road construction. Journal of Applied Chemistry, Vol. 7, Pt. 9, pp. 481-491, Sept. 1957.

Patentverwertungs,
G.M.B.H.
"Hermes" Regenerating of Synthetic Rubber, Belgium Pat. 447,402 (Nov. 30, 1942) (C.A., 39:1080) Ground Synthetic Mixed with Blown Bitumen.

PLIOPAVE
Goodyear Tech. Book Facts Methods PP-2.

Procedings of the Studies on Rubber Asphalts Ministry of Works and Transport. Central laboratory of Bridge and Highways, 58, BD Lefebvre, Paris 15, July 1965.

Rader, L.F.
Investigations of the Physical properties of Asphaltic Mixtures at Low Temperatures. Proc. Assoc. Asph. Pav. Tech., 49, (1935).

Rex, H.H.
Peck, R.A.
Laboratory Study of Rubber-Asphalt Paving Mixtures. Public Roads, Vol. 28, No. 4, Oct. 1954, pp. 91-8.

Rostler, F.S.
Sternberg, H.W.
"Physical and Chemical Fractionation of Asphalts". Ind. and Engr. Chem. Vol. 41. pp. 589-608 (1949).

Rubber Asphalt Roads Roads and Road Construction, Vol. 28 No. 330, June 1950 p 182-3.

Rubber Base Mortar Undergoing Tests. Michigan Roads and Construction, Vol. 56, p. 9 April 9, 1959.

Rubberized Bitumen as Spray Coat, Highways and Bridges and Engineering Works. Vol XVIII No. 893, 15 August, 1961, Highway Research Abstracts, Oct. 1951.

Rubber Crossing Smooths Ride, Material and Methods, Reinhold Publishing Co., 330 West 42nd St., N.Y., N.Y. Vol. 43, pp. 262-64. March 1956, Highway Research Abstracts May 1956. Rubber slabs bolted to highway railroad tie shims.

Rubber in Pavements, Public Works, Vol. 84 No. 7, July 1953, p. 69-70.

Rubber Roads Reap Savings: Goodyear Chemical Review, No. 1, 1966.

Rubberized-Asphalt Road Surface. Engineer, Vol. 169, No. 4396, April 1950, p. 469.

Solomon, G.
Pezzaro, Van Brussel E.
VanDen Schee, A.
Anal. Chem., Vol. 26, No. 8, pp. 1325-1328, Aug. 1954. Analytical Methods. Highway Research Abstracts Oct. 1954.

Satake, S.
Taterbayashi, K.
Reclaiming of Scrap Vulcanized Synthetic Rubber. Japanese Pat. 3143/1950 (C.A., 46: 10676) Mixed with Bituminous Substances.

Shafer, P.
Metzler, W.H.
Report on Use of Rubber Compounds in Asphalt Mixes, Better Roads. Vol. 31, No.8, Aug. 61, p. 15-16.

Shelburne, T.E.
Sheppe, R.L.
Field Experiments with Powdered Rubber in Bituminous Road Construction Virginia Department of Highways, Highway Research Board Bulletin, No. 27, 1950. pp. 13-24.

Field Experiments with Powdered Rubber in Bituminous Road Construction, Rubber Age Vol. 66, No. 5, Feb. 1950, p. 531-8.

Shu-tien, li
Bibliography of Airport Engineering, American Society of Civil Engineers, 1960. (2335 References).

Sinclair, E.A.,
Bristol, K.E.
Reinforcement of Asphalt and Tar by Elastomer Addition. The Goodyear Tire and Rubber Company.

Method for manufacture of rubberized bitumen. U.S. Pat. 3,254,045 (31 May 1966) (To Goodyear) Controlled addition of latex or unvulcanized rubber.

Smith, L.M.
Some viscous and elastic properties of rubberized bitumens. J. Applied Chem. Vol. 10, pt. 7, July 1960, pp. 296-305.

Strieter, O.G.
Method for Determining the Components of Asphalts and Crude Oils. Research Paper RP 1387, Journal of Research of the National Bureau of Standards, May, 1941

Surveyor, Natural Rubber for Roads, Vol. 117, No. 3475, p. 1163, Nov. 29, 1958.

Test Road, Utah. Chemical & Engineering News. p. 33 May 26, 1969. Synthetic Rubber Addition Test.

Thompson, P.D.
A cheaper rubber bitumen using latex. Rub. Dev. Vol. 14, No. 2. pp. 61-64, 1961.

The effects of natural rubber on road binders and their contribution to improvements in road surfaces. Road International, No. 55, pp. 30-38, Dec. 1964.

Full scale road experiments using rubberized surfacing materials 1953-63, Gt. Brit. Road Research Laboratory Road Res. Tech. Paper 71, 1964.

Use of natural rubber in road surfacings, N.R.P.R.A. Tech. Bull. No. 9, Nov. 1964.

Use of Rubber in Bitumen for road surfacing. Engineering, Vol. 172 No. 4466 Aug. 31, 1951, p. 268-9.
Use of Rubber in road surface preparations. Engineering, Vol. 192, No. 4987. Nov. 1961, p. 642.

U.S. Rubber Reclaiming Co. Incorporated Reclaim Rubber in Asphalt. Heat, Agitation, Asphalt pen less than 10 @ 77°

Van Oort, W.P.
"Oxygen Absorption of Asphalt" Ind. and Engr. Chem., Vol. 48, pp. 1196-1201 (1956).

Vokac, R.
Synthetic rubber in asphalt compound. International Inst. of Syn. Rubber Producers, Inc. April 1965.

Synthetic Rubber/Asphalt Compounds in Paving Mixtures. International Inst. of Syn Rubber Producers, Inc. Aug. 1965.

Welborn, J.Y.,
Babashak, J.F., Jr.
New rubberized asphalt for roads. ASCE-Proc., Vol. 84, (J. Highway Div.) n HWA May 1958.

Whiting, S.J.
U.S. Pat. 142,601,20 Aug. 1873, Improved composition for pavements. Addition of Rubber to Pavement Mix.

Wildeboer
Does rubber in roads pay? Rubber Dev. Vol. 13, No. 4, p. 127 (1960).

Winters, W.F.
Whats new in asphalts, petroleum refiner, Vol. 34, No. 4, Apr. 1955, p. 125-6.

Barytes in Rubber - Asphalt Mixtures AAPT Proc. Vol. 25, 1956, pp. 379-391.

Wood, Paul R.
Rheology of Asphalts and the Relation to Behavior of Paving Mixtures. Highway Research Board, Bulletin 192.

(Miller, H.C.) Rheology of Bitumens and the parallel plate microviscometer, paper presented Jan. 1950 to Highway Research Board Meeting.

Testing of Reclaimed Rubber

Ambelang, J.C., and Smith, G.E.P., Jr. Behavior of reclaiming agents in sulfur and non-sulfur GR-S vulcanizates. Ind. Eng. Chem., 46: pp. 1716-21 (1954); repr. in Rubber Chem. Tech., 28: pp. 322-34 (1955). (C.A., 48:14279; R.A., 32:510).

Ball, J.M., and Randall, R.L. Laboratory methods of dynamic testing of compounds containing reclaimed rubber. Rubber World, 130: pp. 795-800 (1954). (C.A., 48:14274; R.A., 32:266,566).

Busenburg, E.B. Testing butyl reclaimed rubber. Rubber Age, 70: p. 608 (1952). (C.A., 46:5354; R.A., 30:187).

Cooper, L.H.N. and Daynes, H.A. Absorption of water by rubber II. Tests on some mixings containing reclaim. J. Rub. Res., 6: pp. 133-38 (Oct., 1937). (C.A., 32:1513; S.C.L., 15:743; B.C.A. (B), 87-1938).

Endo, H. Studies of reclaimed rubber. V. Plasticity of reclaim. 3. Relation between chloroform extract and plasticity of reclaim. 4. Effect of softeners and some other materials on the plasticity of reclaim. J. Soc. Rubber Ind. Japan, 13: pp. 466-76, 829-53; English abstracts on pp. 915-21 (1940). (C.A., 35:8366).

Gillman, H.H., Thoman, R., and Chalmers D. Mechanical stability of dispersed reclaim. R.A. (N.Y.), 56: pp. 60-62 (1944). (C.A., 39: 1317; S.C.L., 23:150). Data on newly developed test.

Hurukawa, T.A. Consideration of the Error Factor with Reference to the Dissolution of Alkaline Materials from Glassware in the Free Alkali Determination of Reclaimed Rubber. J. Soc. Rub. Ind. Japan, 12: No. 11, pp. 716-19, English abst. on pp. 761-62 I Nov. (1939).

Kato, Y., and Nakazawa, M. Studies of reclaimed rubber. II. Effect of organic accelerators, fillers and hardening materials on the vulcanization of reclaimed rubber. Rept. Imp. Ind. Research Inst., Osaka, Japan, 21: No. 1, 47 pp. (1940). (C.A., 35:929).

Kheraskova, E., and Paramonova, E. Determination of cellulose in reclaimed rubber. J. Rub. Ind. (U.S.S.R.). 432-33 (1936). (C.A., 30:5455).

Kilbourne, F.L. Misner, J.E., and Fairchild, K.W. Plasticity of reclaimed rubber. R.A. (N.Y.), 66: pp. 123-28 (1950). (C.A., 44: 3292; S.C.L., 28:215).

Kilbourne, F.L., Jr. Testing reclaimed rubber. R.A. (N.Y.), 62: pp. 541-42 (1948); repr. in Rubber Chem. Tech., 21: pp. 769-72 (1948). (C.A., 42:2808; S.C.L., 26:636). Test formula given.

Kimura, Y. Analytical Results on Some Commercial Reclaimed Rubber. Waseda Applied Chem. Soc. Bull., 16: No. 2, pp. 1-2, English abst. on p. 18 (1939). (C.A., 34:3536; S.C.L., 18:395).

Kuchinskaya, K., and Panov. N. Physicochemical Constants of the Hydrocarbon Fraction Used for Regenerating Rubber. Sbornik Trudov Opytnogo Savado im. Akad S.V. Lebedeva, pp. 50-52 (1938); Khim Referat, Zhur., 2: No. 4, p. 24 (1939). (C.A., 34:1513; S.C.L. 18:257).

LeBeau, D.S. Basic reactions occurring during reclaiming. II. Effect of aging of the scrap, storage of the reclaim, and the effect of solvent naphtha on reclaiming of natural rubber. I.R.W., 119: pp. 69-79 (1948). (C.A., 43:1600; S.C.L., 27:62).

LeBeau, D.S. Basic reactions during reclaiming. I. Influence of temperature, antioxidant, and defibering agents on natural rubber. IRW 118: pp. 59-65 (1948); repr. in Rubber Chem. Tech. 21: pp. 895-908 (1948). (C.A., 42:5253; S.C.L., 26:636). II. Effect of aging of the scrap, storage of the reclaim, and of solvent naphtha on reclaiming of natural rubber. I.R.W., 117: p. 760 (1948). (C.A., 43:1600: S.C.L. 26:369; R.A., 62:667).

LeBeau, D.S. Structure of polymers and its influence on their behavior during reclaiming. R.A. (N.Y.) 62: pp. 51-55 (1947). (C.A., 42:1445; S.C.L., 26:194). GR-S polymer formed in initial heating recombines as heating continues.

LeBeau, D.S. Quantitative estimation of GR-S in rubber reclaim Analy. Chem., 20: pp. 355-58 (1948). (C.A., 42:5705; S.C.L., 26: 450).

Lewis, J. Reclaiming rubber and the testing of the products. Trans. Inst. Rubber Ind. 18: pp. 282-85 (Apr., 1943). (C.A., 37:5282).

Lewis, J. Essex, W.G. Cornwell, G.W., and Mackusick, M.H. Cause of Increase in Shore Hardness on Storing Vulcanized Compounds. I.R.J. 97: pp. 526, 620, 712; (1939). (S.C.L., 17:547).

Minatoya, S., and Furukawa, T. Properties of the chloroform extract of reclaimed rubber. II. Analytical study of the chloroform extract of commercial reclaimed rubbers. J. Soc. Rubber Ind., Japan, 15: pp. 685-94 (1942). (C.A., 43:3226; S.C.L., 27:688).

Minatoya, S. Kobayashi, K. and Kato H. Depolymerization effect of zinc oxide. J. Soc. Rubber Ind., Japan. 20: pp. 159-60 (1947). (C.A., 45:6416; S.C.L., 29:928).

Mocker, F. and Old, I. Polarographic investigations of vulcanizates employing dibenzthiazyl disulfide as accelerator and reclaim of these, as an analytical contribution to the explanation of the vulcanization process. Kautschuk Gummi 15 (5). WT143. 145-6 (1962). (C.A., 56:3609; R.A., 40:425).

Moakes, R.C.W., and Scott, J.R. Vulcanization testing of reclaim: Relation between results obtained in reclaim-sulfur and tire tread mixes. J. Rubber Research, 15: pp. 207-13 (1946); repr. in Rubber Chem. Tech., 20: pp. 301-07 (1947). (C.A., 41:307; S.C.L., 24:561).

Newton, R.G. Analysis of reclaim. I.R.J., 107: p. 230 (1944). S.C.L., 22:331). A discussion of effects of the reclaiming process.

Palmer, H.F., and Crossley, R.H. Test formulas for reclaimed rubber. Ind. Eng. Chem. (Anal. Ed). 13: pp. 154-56 (Mar. 15, 1941). See also: Testing reclaims. Can. Chem. Process Ind., p. 272 (May, 1940).

Palmer, H.F., and Crossley, R.H. Reclaimed rubber: Application of the T-50 test. Ind. Eng. Chem. (Ind. Ed.), 32: pp. 1366-71 (Oct. 1940).

Provinteev, I.V., Pliner S.A. and Kotlova R.A. Determination of the Degree of Homogeneity of Rubber-bitumen compositions based on reclaim. Sov. Rubb. Tech. vol. 26 no. 3 p. 47 (1967) Method of Analysis.

Rheim Chemie Gmbh Mannheim-Rheinau 1965 Test Methods – Physical tests. 1965 test methods – Chemical Tests.

Rigbi, Z. Chloroform extract of reclaim. Rubber J. Intern. Plastics 139 (24), 974 (1960). (R.A., 39:79). The extraction is described.

Sembra, T., and Ooki, S. Some consideration on the Alkalinity Determination of Reclaimed Rubber. J. Soc. Rub. Ind. Japan, 12: No. 12, pp. 770-79, English abst. on p. 865 (Dec., 1939).

Shobayashi, G. Evaluation of reclaimed rubber as a substitute for raw rubber. I. Comparison of the mechanical strength of new rubber vulcanizates with that of reclaimed rubber vulcanizates. II. Comparison of new rubber and commercial reclaimed rubber from the standpoint of tensile properties. III Confirmation of the conversion factors obtained in the preceding work in practical use. J. Soc. Rubber Ind., Japan 15: pp. 514-28 (1942). (C.A., 43:4889; S.C.L., 27:784).

Shobayashi, G. Physical tests of vulcanized rubber. Use of large percentages of reclaimed rubber. J. Soc. Rubber Ind. Japan, 15: pp. 571-80 (1942). (C.A., 43:3226; S.C.L., 27:604).

Stafford W.E. Rigby V. Technical Control in Rubber Reclaiming. Proc. Inst. Rubber Ind. (41) 161 (1965). Quality of product, testing and methods.

Stafford, W.E., Sargent, D.T., and Allcroft, J.B. Some aspects of rubber combined sulfur on reclaiming. Rubber J. Int. Plast., 134: pp. 245-46, 248 (1958). (R.A., 36:160) Thermal breakdown of different types of natural and butyl vulcanizates have been studied.

Sverdrup, E.F., Plumb, J.S., and Elgin J.C., Reclaiming of vulcanized rubber: Rate of replasticiation. (Abstracts only). R.A. (N.Y.), 64: p. 46 (1948); I.R.W., 119: p. 223 (1948).

Taranenko, I.T., and Suchkova, M. Determination of textile matter in rubber reclaim. Legkaya Prom., No. 7-8: pp. 17-18 (1944). (C.A. 39:4515; S.C.L., 24:37). Analytical method.

Trius, V. Determination of the quality of a reclaimed rubber. Caucho. Bol. Inform. Consorcio Fabr. Articulos Caucho 1961 (132), 35-9 (R.A., 39:533). A review of tests.

Tyler, Williard P., Rub. Chem. and Tech. vol. 40, no. 1, p. 238 Feb. (1967) Analysis, Composition, and Structure of rubber and rubber products.

Winkelann, H.A. Comparison of some reclaimed rubbers. (abstracts only) R.A., (N.Y.), 65: p. 57 (1949); I.R.W., 120: p. 91 (1949). (S.C.L., 27:689).

Yoshida, J. Physical Properties of Reclaimed Rubber Stocks. J. Soc. Rub. Ind. Japan, 12: No. 10, pp. 650-55, English abst. on pp. 682-83 (Oct. 1939). (C.A., 34:6485).

Types of Reclaim

Bannister, E. and Zapp, R.L. Depolymerization of chlorinated butyl rubber. Brit. Pat. 926,809 (May 22, 1963). (To Esso Research & Eng. Co.). (R.A. 41:413).

Bata, A.S. Regeneration of synthetic rubber. French Pat. 885,895 (Sept. 28, 1943). (Chem. Zentr., 115; No. 1, 1140-41). Heating butadiene or chloroprene rubber with dithiocarbamic acid derivatives, thiazole, thiazyl sulfide, thiuram sulfide or debenzothiazyl disulfide.

Bata, A.S. Regeneration of natural or synthetic rubber. French Pat. 885,896 (Sept 28, 1943). (Chem. Sentr., 115, No. I, 1047). Treatment of vulcanized rubber. chloroprene, buna or butadiene rubber with organic sylfonyl chlorides under heat and pressure.

Bata Narodni Podnik. Regenerating vulcanized rubberlike polymers of chloroprene. Netherlands Pat. 67,287 (Jan. 16, 1951). (S.C.L. 29:265).

Beaver, D.J. Oil-resistant thermoplastic and method of making. U.S. Pat. 2,382,462 (Aug. 14, 1945). (To Monsanto Chemical). (C.A., 39:5547) Intimately mixing scrap rubber or reclaimed rubber with polyldichlorphosphine and retane and heating.

Bina, J. and Cernuska, O. Reclaim from silicone rubber. Chem. Prumysl. 13 (2): 112 (1963). (R.A., 42:253).

Brown, G.L., Johnson, T.A., and Knill, R.B. Non-discoloring reclaim U.S. Pat. 2,640,035 (May 26, 1953). (To Wingfoot Corp.). (C.A., 47: 7814; R.A., 32:57). Devulcanizing with a light colored rosin oil.

Campbell, C.H., Oil-resin reclaiming blend. U.S. Pat, 2,468,482 (Apr. 26, 1949). (S.C.L., 27:603).

Castello, A.D. Peptized vulcanizate and method of preparing it U.S. Pat. 2,211,592 (Aug. 13, 1940). (To Goodrich). Reclaiming well-vulcanized soft rubber by adding an organic material to accelerate the vulcanization and masticating below 180°F.

Castello, A.D., and Dixon, H.L. Reclaimed rubber. U.S. Pat. 2,278,826 (Apr. 7, 1942) (To Goodrich). (C.A., 36:6376) Preparing a nonstaining composition by admixing vulcanized rubber, an absorbent material, and a water-insoluble soap, and heating the mixture in the presence of an alkali.

Cech, C.J., and Bata, A.G. Reclaiming of synthetic rubber composed of polymers of butadine or its alkyl or halogen derivatives. German Pat. 743,605 (1943). Kunststoffe 34:24; S.C.L., 22:209).

Comments on the article on "Solution Reclaim". R.A. (N.Y.) 53: pp. 339, 368 (1943). (S.C.L., 21:268).

Dasher, P.J., Reclaiming vulcanized copolymers of butdaiene and acrylonitrile U.S. Pat. 2,465,205 (Mar. 22, 1949). (To Goodrich). (C.A., 43:4510; S.C.L., 27:422). Acrylic ester.

Eby, L.T. Reclaiming synthetic olefin-polyolefin-rubbery polymers U.S. Pat. 2,471,866 (May 31, 1949). (To Standard Oil). (C.A., 45:9259; S.C.L., 27:669).

Flood, D.W., and Mulligan R.A. Method of and apparatus for reclaiming latex foam. U.S. Pat. 2,719,830 (Oct. 4, 1955). (To U.S. Rubber). (C.A., 50:3793; R.A., 34:828). Alkali or borate.

Fuchs, H. Solution reclaim. R.A. (N.Y.) 52: pp. 397-98 (1943) (C.A., 37:1897).

General Electric Co., Reclaimed silicone rubber. Brit. Pat. 760,004 (Oct. 31, 1956). (R.A., 35:84).

Ghez, H.C. Reclaim compounds with no crude rubber; Nervastral processes. I.R.W., 106: pp. 142-45 (May 1942). (C.A., 36:6047).

Goyert, M. Swelling behavior of synthetic rubber reclaim in organic substances. (abstract only) Kaut. u. Gummi, 12: No. 6, p. WT168 (1959) (R.A., 37:450). Perbunan reclaim.

Green, J. and Sverdrup, E.F. Carboxylic rubbers from scrap vulcanized rubber. Rev. Gen. Caout., 34: pp. 25-32 (1957). (R.A., 35:215).

Griffin, W.R. USP 329,1761 Reclaiming Viton Reclaims via acetone, acetic acid and permanganate.

Gummiwerke Odgewald GmbH. Reclaim. Ger. Pat. 1,170,621 (May 21, 1964); Ger. Pat. Abstr., 4 (25): 2 (1964). (R.A., 42:536).

Guzzetta, G. Castellanza, F.S. and Gechele, G.B. Depolymerization of styrene in the presence of free radical generating substances. U.S. Pat. 3,143,536 (Aug. 6, 1964). (To Montecatini).

Hill, N.C. Reclaiming rubber U.S. Pat. 2,806,821 (Sept. 17, 1957). (To C.P. Hall Co.). (C.A., 52:1966); (R.A., 36:160). Natural rubber and GR-S.

Hoover, C.F. Butyl reclaim. Rubber Age, 76: p. 725 (1955). (C.A., 49:9315; R.A., 33:209).

Hurley, R.T. Method for reclaiming scrap polyurethane resins U.S. Pat. 3,143,515 (Aug. 4, 1964). (To Reeves Bros., Inc.).

Ikuta, S., Tsuzuki, Y., and Takaoka, Y. Mixing GR-I and GR-S reclaim with natural rubber. J. Soc. Rubber Ind., Japan, 22: pp. 100-06 (1949). (C.A., 46:379-; R.A., 30:289).

Khodkevich, L. Production of colored reclaim by means of chemical accelerators of reclaiming. Leka. Prom., 8: No. 5, pp. 26-27 (1959). (R.A., 38:383). The cost about the same as black reclaim.

Kirby, W.G., and Elliott, P.M. Process of reclaiming waste polychloroprenes. U.S. Pat. 2,343,558 (March 7, 1944) and Can. Pat. 431,501 (Nov. 27, 1945). (To U.S. Rubber). (C.A., 41:4952; S.C.L., 25:207).

Konig, W. Foamed materials from scrap-expanded polyurethanes. German Pat. 962,649 (April 25, 1957). (To R. Koepp & Co). (R.A., 36:232). Alternatively the scrap may be dissolved in hot polyisocyanate and the polyester added.

LeBeau, D.S. Powdered reclaim. Rubber Age, 73: pp. 785-91 (1953). (C.A., 48:1045; R.A., 31:163,507).

Lipetz, S. and Lipetz, A. Reclaiming nylon scrap. Brit. Pat. 936,828 (Sept. 11, 1963). (R.A., 42:55).

McCowan, W.A. Reclaiming polymeric siloxane scrap. Brit. Pat. 716,024 (Sept. 29, 1954). (To Dunlop). (R.A., 33:31). Rubber scrap is heated in oxygen-free atmosphere.

Metallgesellishaft, A.-G., Rhenania Ossag., and Mineralolwereke, A.-G. Mixtures of rubber, rubberlike substances, synthetic rubber and synthetic resins. French Pat. 889,110 (S.C.L., 23:235; Rev. Gen. Caout., 21:42).

Metalurgical International, Inc. Chem. Engr. News, 45, no. 38, Sept. 67, p. 36, Impact Process Reclaims PTFE scrap. Coldstream process for teflon and halon.

Midland Silicones, Ltd. Reclaiming siloxame elastomers. Brit. Pat. 752,860 (July 18, 1956). (R.A., 34:502). Anhydrous hydrogen chloride.

Mishustin, I.U. Production of reclaimed rubber containing fibers. Kauchuk i Rezina, No. 7, pp. 24-28 (1940). (C.A., 34:8335). From all synthetic rubber containing 20-25% vegetable fibers.

Moore, D.V., and Thompson, H.H. Reclaiming method. Can. Pat. 429,743 (Aug. 28, 1945) and U.S. Pat. 2,386,707 (Oct. 9, 1945). (To Wingfoot Corp.) (C.A., 39:5121; 40:763). Reclaiming a cured butadiene copolymer with styrene or acrylonitrile by heating with a swelling agent which contains ethyl alcohol as a plasticizer.

Nezval, F. Production of reclaim from natural or synthetic rubber Czechoslovakian Pat. 83,763 (Jan. 3, 1955). (R.A., 35:586). Leather scrap is subjected to the process of reclaim along with the comminuted rubber.

Osipovskii, B.Y. and Mamontov, B.V. Reclaiming sodium-butadiene rubber. Kauchuk i Rezina, No. 4, pp. 61-67 (1940). (C.A., 34:7658).

Pacevitz, H.A. Recovery process for chlorinated rubber. U.S. Pat. 2,396,000 (Mar. 12, 1946). (To Wingfoot Corp.). (C.A., 40:3640; S.C.L., 24:281).

Pellison, J. Reclaiming crepe sole scrap. French Pat. 983,030 (June 18, 1951). (R.A., 30:54).

Phoenix Gummi-Werke. A.–G. Regenerated rubber. Ger. Pat. 1,132,328 (June 28, 1962): Ger. Pat. Abstr. 2 (30), 2 (1962). (R.A., 40,492). Heating ground vulcanized scrap rubber which contains nitrogen-containing rubber auxiliaries, e.g. antioxidants such phenyl-B-naphthylamine with methylol compounds of phenol produces compounds which are insoluble and no longer diffusible in rubber; the reclaim is colorless or only slightly colored.

Polyplast Gesellschaft Fur Kautschukchemi m.b.H. Regeneration of scrap rubber. Brit. Pat. 761,478 (Nov. 14, 1956). (R.A., 35:114). Balata and gutta-percha is reclaimed by mixing with an oxidized extract of a mineral lubricating oil.

Proell, W.A. Thiosulfenyl chlorides and bromides and polymers made therefrom U.S. Pat. 2,684,952 (July 27, 1954). (To Standard Oil Co.). (R.A., 33:73). Polysulfide rubbers reclaimed by reacting with chlorine.

Quinn, N.G. Vulcanizing of ebonite; controlled curing of natural and synthetic rubber ebonites of large cross-section. I.R.J., 105: pp. 62-63 (July 17, 1943). (C.A., 37:6494). Repr. in Rubber Chem. Tech. 17: pp. 192-93 (1944).

R.D.L. Bib Reclaiming Foam Matls Vol. Mar. Yr. 60 Ln. 2 Rub. Div. Lib.

Regeneration of S.K. Kauchuk i Rezina, No. 11: pp. 63-73 (1939). (I.R.W., 109,479).

Riolfo, R. "Reversion" method for reclaiming silicone elastomer scraps Rev. Gen. Caout., 34: pp. 352-54 (1957). (R.A., 35:444).

Rothermel, E.M. Natural and reclaimed rubbers. Rubber World 135: pp. 892-94 (1957). (R.A., 35:260). Method of preparing smoked sheet and pale crepe and nine reasons for using reclaim.

Rubber Reclaiming Co. B.P. 1009592 Recovery of nylon from tyre scrap. Using 60-75% aqueous formic acid.

Santholzer, R.Reclaiming silicone rubber. Plastics Design Process 3 (5): 11 (1963). (R.A., 41:486). Four methods are given.

Sarada, M. Regenerated rubber. Japanese Pat. 177,783 (Feb. 15, 1949). (C.A., 45:9910; R.A., 30:110). Mixed with waste liquor from sulfite pulp.

Semperit Gummiwerk G.P. 1218715. Reclaimed Rubber, Pretreat rubber with aldehydes in presence of dil. H_2SO. This type can be used in contact with white or light-colored PVC without discoloration.

Shokhin, I. Rubber Reclaim Stocks Vol. 18 No. 3 Page 34 Yr 59 Ln 6 Sov. Rub. T.

Slobodin, Y.M. and Matusevich, N.I. Polymerization and depolymerization. I Depolymerization of rubberlike polymers of isobutylene. J. Gen. Chem. (U.S.S.R.) 16: pp. 2077-82 (1947). (C.A., 41:7803, S.C.L., 26:108).

Societe des Usines Chimiques Rhone-Poulenc. Process for the reclaim of organopolysioxane elastomers. French Pat. 1,169,639 (Dec. 31, 1958). (Rev. Gen. Caout., 36:370; R.A., 37:344) by heating in suitable atmosphere at a temperature between 150 to 350°C.

Stover, A.M. Method of preparing aqueous dispersion of reclaimed rubber. U.S. Pat. 2,377,052 (May 29, 1945). (To Goodrich). (C.A., 39:3968; S.C.L., 23:306). Admixing with the reclaimed rubber not more than 30 parts of carbon black per 100 parts of reclaimed rubber and thereafter adding a saponaceous dispersing agent.

Svensson, O. Dissolving vulcanized rubber waste. Swedish Pat. 104,698 (1946). (C.A., 40:7692; S.C.L. 25:367).

Sverdrup, E.F., and Elgin J.C. Reclaiming rubber. U.S. Pat. 2,415,449 (Feb. 11, 1947). (To U.S. Rubber Reclaiming Co.). (C.A., 41:3660; S.C.L., 25:291). Vulcanized conjugated diolefin polymer compositions reclaimed.

Sverdrup, E.F. Reclaiming of rubber and production of hard rubber products. U.S. Pat. 2,809,944 (Oct. 15, 1957). (To U.S. Rubber Reclaiming Co.). (C.A., 52:3392; R.A., 36:209). Free sulfur and continuously kneading.

Sverdrup, E.F. Reclaimed rubber in discrete particle form. U.S. Pat. 2,800,462 (July 23, 1957). (To U.S. Rubber Reclaiming Co). (C.A., 51: 15988; R.A., 36:110). A method of reclaiming neoprene and butyl rubber.

Sverdrup, E.F. Reclaiming vulcanized rubber in the presence of unvulcanized high styrene polymeric material U.S. Pat. 2,845,395 (July 29, 1958). (To U.S. Rubber Reclaiming Co.). (C.A., 52:19230; R.A., 37:66). Natural GR-S, nitrile and butyl rubber can be reclaimed.

Ten Broeck, T.R. and Peabody, D.W. Method for reclaiming cured cellular polyurethane, U.S. Pat. 2,937,151 (May 17, 1960). (To Goodyear). (R.A., 38:637; C.A., 54:19005). Can be used for foams.

Thompson, H.H. Depigmentizing reclaimed rubber. U.S. Pat. 2,365,662 (Dec. 26, 1944). (To Wingfoot Corp.). (C.A., 39:3968; S.C.L., 23:150). Mixing bentonite with the stock and then extracting with a rubber solvent while the bentonite inhibits removal of the carbon black by the solvent.

Thompson, H.H. Rubber reclaim. U.S. Pat. 2,407,193 (Sept. 3, 1946): (To Wingfoot Corp.). (C.A., 41310; S.C.L., 24:561). Process for preparing non-staining reclaimed rubber.

Torrence, M.F., and Schwertz, H.G. Compounding reclaim with new elastomers for high quality at low cost. Rubber Age, 71: pp. 357-60 (1952). (C.A., 46:10672; R.A., 30:366).

Treves, A. Rubber waste processing. Can. Pat. 426,411 (March 27, 1945). A product, reduced by the process of Can. Pat. 426,401, which is soluble in crude rubber solvents.

Tsvetaeva E.M. Kauch i Rezina, 26, no. 6, June 1967, p. 37. Reclaiming of SKD vulcanzates (Stereoregular butadiene rubber) reclaimed with fatty acid, plasticizer, and shale-oil.

United States Rubber Co. Polyamide polymer. Belgian Pat. 636,422 (Feb. 28, 1964).

United States Rubber Co. Reclaiming scrap containing vulcanized copolymers of 1,3 butadiene and monovinyl compounds: reclaiming waste polychloroprenes Brt. Pat. 575,545 (1946). (C.A., 41:6766; S.C.L., 24:252,253,257).

Vanbreen, A.W. Thermoplastic rubbers Vol. 20 No. 9 Page 373 Sept. 1967 len. 9 Lang. Dut. Plastica.

Verein, Glazstoff-Fabrik, A.-G. depolymerization of polyethylene terephthalate. Ger. Pat. 1,143,193 (Feb. 7, 1963). (C.A., 59:7435).

Wallace, E.H. Some notes of reclaim rubber compounds. I.R.J., 103; pp. 633-35 638 (1942) (S.C.L., 20:411).

Warren, S.F., and U.S. Rubber Reclaiming Co., Inc. Reclaiming natural and synthetic rubber. British Pat. 610,901 (S.C.L., 27: 158). Organic disulfide.

Wendrow, B.R., and Spalding, D.P. Silicone rubber reclaim. Rubber World 138: pp. 738-42 (1958). (C.A., 52:21205; R.A., 35:502; 36:502). Silicone rubber can be reclaimed.

Wingfoot Corp. Regenerating copolymers. British Pat. 615,865. (C.A., 45:1378; S.C.L., 27:324). Mix rubber with coal tar distillate and heat.

Winkelmann, H.A. Reclaiming neoprene. U.S. Pat. 2,313,693 (Mar. 9, 1943). (C.A., 37:5284).

Zakharov, N.D., Bogdanovich, N.A. and Volkova, M.I. Reclaim of butadiene-nitrile rubber. Izy, Vyssh. Uchebn. Zaved. Khim. i Khim Tekhn., 3: No. 3, pp; 527-33 (1960). (R.A., 38:637; C.A., 54:23397) Used in brake lining.

Waste From Rubber Industry

Heap, Morrell, Journal App. Chem. vol. 18, no. 7 p. 189 Microbiological Deterioration of Rubber and Plastics. Fillers more susceptible to microbe destruction.

Heinisch, K.F. and Nadarajah, M. Disposal of factory effluents from crepe and sheet producing factories. I.II. Rubber Res. Inst. Ceylon Quart. J., 39 (1-2): 32:37 (1963). (R.A., 41:551). The main effluent is rubber serum (acid in reaction) diluted with water, which can be rendered innocuous by passage through a series of tanks, one of which contains limestone.

Lewis, S.C. Reclaimed rubber. Waste Trades Manual and Directory pp. 61,63,65 (1948). (S.C.L., 27:348).

Rostenback, R.E. Synthetic rubber wastes. Sewage & Ind. Wastes, 24: pp. 1138-43 (1952). (C.A., 46:11752; R.A., 31:455).

Rostler, F., and Mehner-Wilson, V. Reclaim from vulcanized rubber scrap. German Pat. 909,041 (March 4, 1954). (To Metallgesellschaft Aktienges. Naftolen Ges. m.b.H.). (R.A., 33:59). Refinery wastes.

Rubber Raw Materials, Ltd. Diversity of rubber scrap. Rubber Age & Synthetics, 33: p. 137. (1952). (R.A., 30:310).

Ruchhoft, C.C., Placak, O.R., and DeMartini, F.E. Investigations disclose successful disposal methods for synthetic rubber waste. Civil Eng., 17: No. 2, pp. 59-60 (1947). (C.A., 41:7806, 7807; S.C.L., 26:104). Coagulation, ozaonation, addition of activated carbon, breakpoint chlorination and aeration.

United Kingdom Ministry of Supply. Utilization of synthetic and natural rubber waste. Advisory Service on Rubber, Circular No. G-4 (May, 1946). (S.C.L., 24:350).

Wilson, A.W.G. Junk and industrial wastes. Can. Chem. Process Ind., 25: pp. 163-67 (Apr. 1941). Importance of scrap.

Zigmund, V.A., and Petroy, M.V. Crude rubber waste. Kauchuk i Rezina No. 7: pp. 50-51 (1940). (S.C.L., 24:444, I.R.W., 114:374).

Waflet, F.E. Reclaimed rubber. A little publicized domestic source of supply. Chemical industries, 47: No. 1, pp. 27-29 (July 1940). Review of American facilities.

Yasunkskaya, F. Problems in the economics of using reclaim Kauchuk i Rezina, 18: No. 1, p. 54 (1959). (R.A., 37:428), A plea is made for a more extensive use of reclaim.

μσ403